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Department of Agriculture, Fisheries and Forestry
Biosecurity

Final report for the non-regulated analysis of existing policy for fresh mangosteen fruit from Indonesia

June 2012

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The picture of mangosteen fruit on the front cover was obtained from Directorate General of Horticulture (2011) Jakarta, Indonesia.

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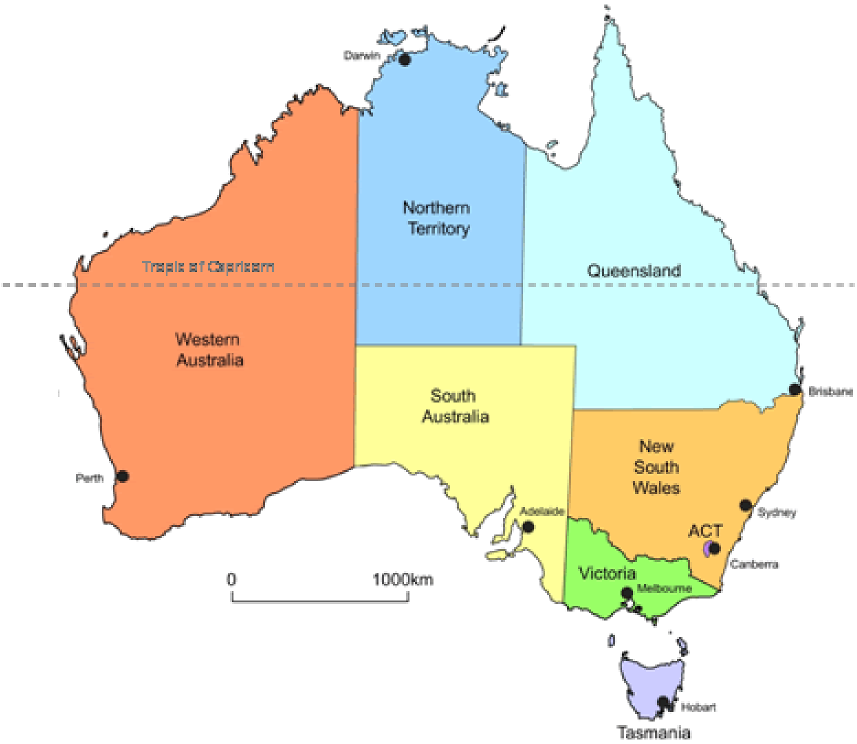
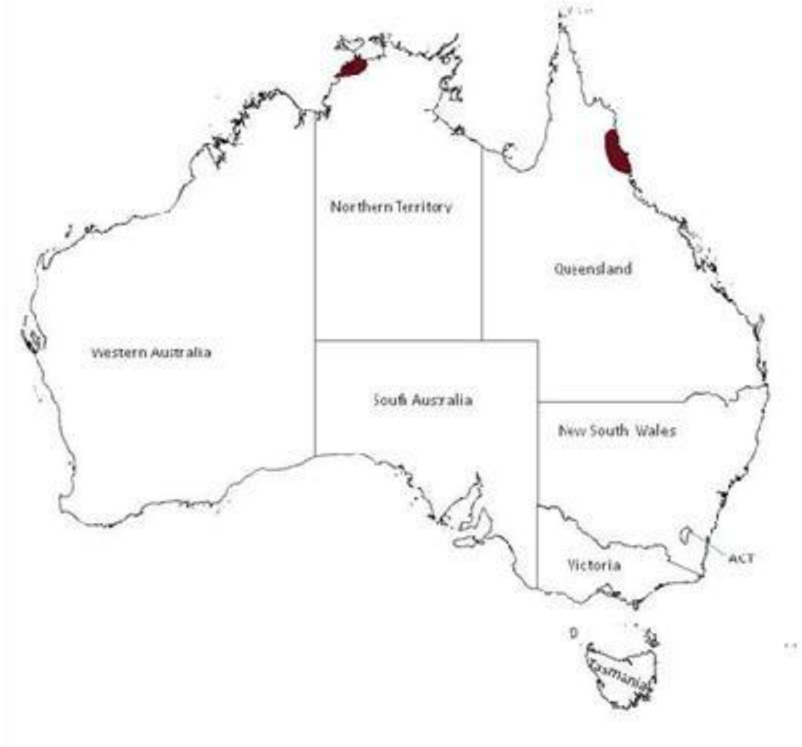


Figure 1 **Map of Australia**



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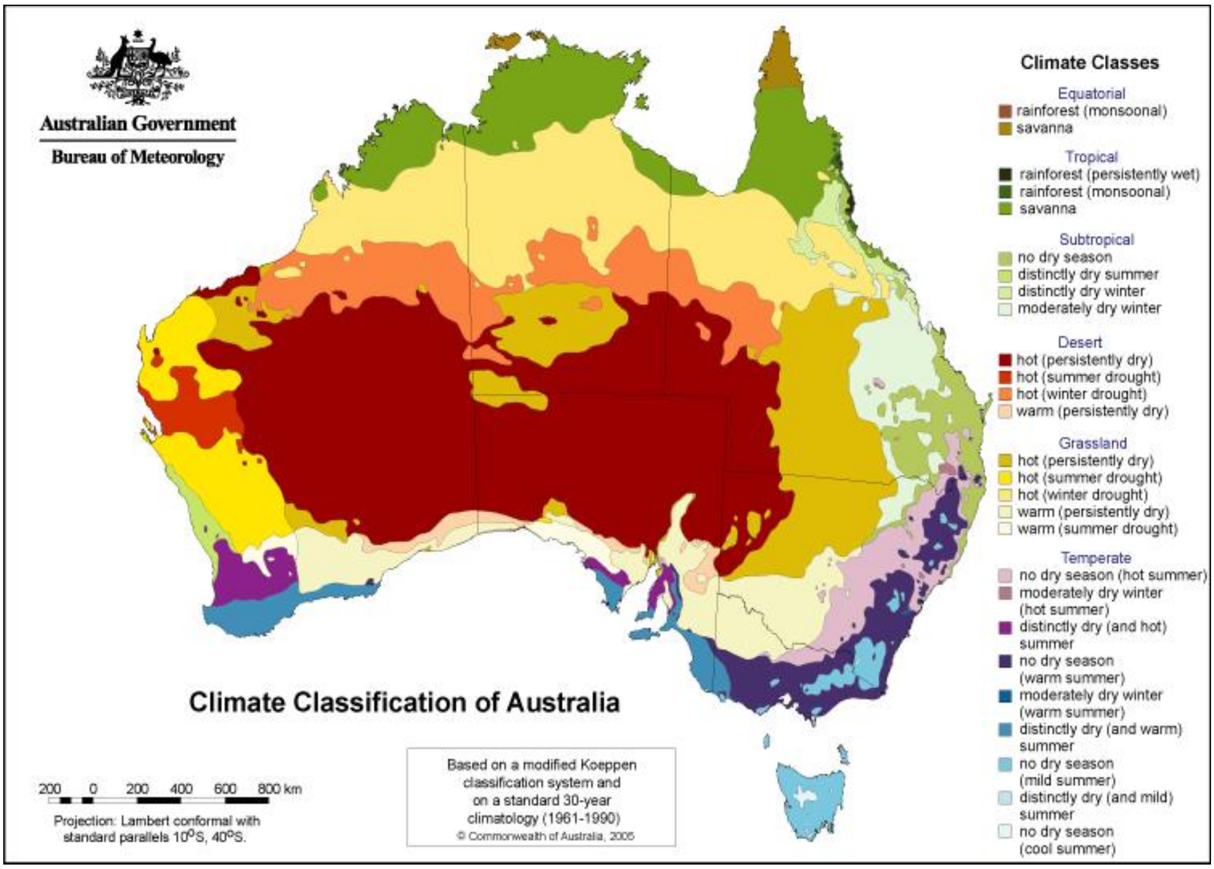

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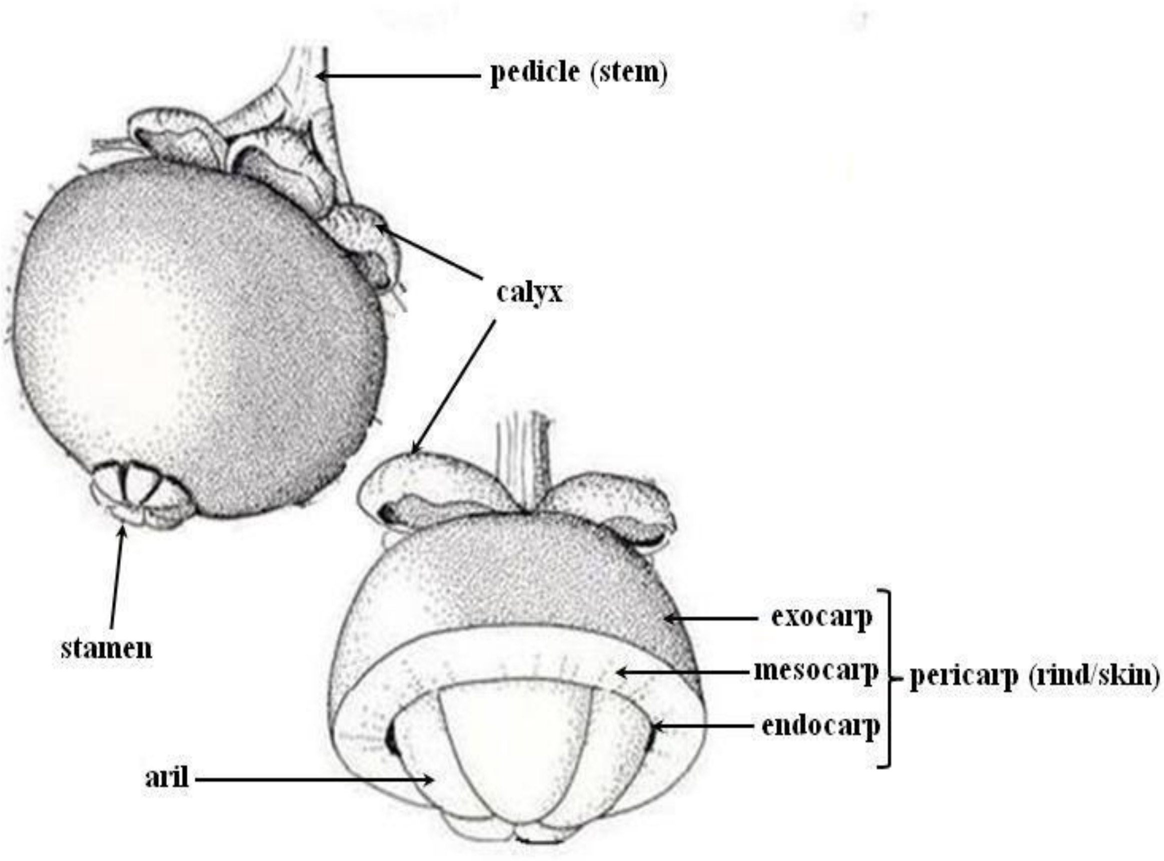

Figure 4 **Diagram of a mangosteen fruit (modified from Osman and Milan 2006)**

Acronyms and abbreviations

Term or abbreviation	Definition
ACT	Australian Capital Territory
AFAS	Australian Fumigation Accreditation Scheme
ALOP	Appropriate level of protection
AQIS	Australian Quarantine and Inspection Service
BA	Biosecurity Australia
BAA	Biosecurity Australia Advice
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
DGH	Indonesia’s Directorate General of Horticulture
DNA	Deoxyribonucleic acid
DSEWPC	Australian Government Department of Sustainability, Environment, Water, Population and Communities
EP	Existing policy
FAO	Food and Agriculture Organization of the United Nations
GAP	Good Agricultural Practice
GHP	Good Handling Practices
IAQA	Indonesian Agricultural Quarantine Agency
ICON	AQIS Import conditions database
IPC	International Phytosanitary Certificate
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IRA	Import Risk Analysis
ISPM	International Standard for Phytosanitary Measures
NSW	New South Wales
NPPO	National Plant Protection Organisation
NT	Northern Territory
OIE	World organisation for animal health
PRA	Pest risk analysis
Qld	Queensland
SA	South Australia
SOP	Standard Operating Procedure
SPS	Sanitary and Phytosanitary
SSOP	Sanitation Standard Operation Procedure
Tas.	Tasmania
USA	United States of America
Vic.	Victoria
WA	Western Australia
WTO	World Trade Organization

Abbreviations of units

Term or abbreviation	**Definition**
ºC	Degree Celsius
ºBx	Degree Brix
cm	Centimetre
g	Gram
kg	Kilogram
km	Kilometre
m	Metre
mm	Millimetre
s	Second

Summary

This final report for a non-regulated analysis of existing policy assesses a proposal from Indonesia for market access to Australia for fresh mangosteen fruit.

This final report recommends that the importation of fresh mangosteen fruit to Australia from all commercial production areas of Indonesia be permitted, subject to a range of quarantine conditions.

Australia permits the importation of mangosteens from Thailand for human consumption provided they meet Australian quarantine requirements.

This report identifies pests that require quarantine measures to manage risks to a very low level in order to achieve Australia's appropriate level of protection (ALOP). The pests requiring measures are species of spider mites, mealybugs and ants. While fruit flies are pests of concern, mangosteen fruit are considered conditional non-hosts when undamaged and at specific maturity levels.

The recommended quarantine measures take account of regional differences. Only one pest requiring risk mitigation, a mealybug species, has been identified as a regional quarantine pest for Western Australia.

This report recommends a combination of risk management measures and operational systems that will reduce the risk associated with the importation of mangosteen fruit from Indonesia into Australia to achieve Australia's ALOP, specifically:

- packing of undamaged fruit of maturity index of 2–3 (fruit with reddish spots or reddish skin) because such fruit does not host fruit flies.
- a systems approach (cleaning of the fruit, including under the calyx, using pressurised air blasting and brushing, fumigation with methyl bromide, and regulatory visual inspection and remedial action) for spider mites, mealybugs and ants.
- a supporting operational system to maintain and verify the phytosanitary status of consignments. DAFF Biosecurity will verify that the proposed phytosanitary measures have been applied.
- pre-export phytosanitary inspection and certification by the Indonesian Agricultural Quarantine Agency (IAQA) and on-arrival phytosanitary inspection, remedial action if required, and clearance by DAFF Biosecurity.

This report contains details of the risk assessments for the quarantine pests and the recommended quarantine measures.

DAFF Biosecurity has carefully considered all stakeholder comments on the draft report. The report has been amended to take account of all scientifically relevant comments and information.

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[1] 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 import risk analysis (IRA) process is an important part of Australia's biosecurity policies. It enables the Australian Government to formally consider the risks that could be associated with proposals to import new products into Australia. If the risks are found to exceed Australia's appropriate level of protection (ALOP), risk management measures are proposed to reduce the risks to an acceptable level. But, if it is not possible to reduce the risks to an acceptable level, then no trade will be allowed.

Successive Australian Governments have maintained a conservative, but not a zero-risk, approach to the management of biosecurity risks. This approach is expressed in terms of Australia's ALOP, which reflects community expectations through government policy and is currently described as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's IRAs are undertaken by DAFF Biosecurity using technical and scientific experts in relevant fields, and involves consultation with stakeholders at various stages during the process. DAFF Biosecurity provides recommendations for animal and plant quarantine policy to Australia's Director of Animal and Plant Quarantine (the Secretary of the Department of Agriculture, Fisheries and Forestry, DAFF). The Director, or delegate, is responsible for determining whether or not an importation can be permitted under the *Quarantine Act 1908*, and if so, under what conditions. DAFF Biosecurity is responsible for implementing appropriate risk management measures.

More information about Australia's biosecurity framework is provided in Appendix D of this report and in the *Import Risk Analysis Handbook 2011* located on the DAFF website www.daff.gov.au.

1.2 This import risk analysis

1.2.1 Background

The Indonesian Agricultural Quarantine Agency (IAQA) formally requested market access for fresh mangosteen fruit to Australia in a submission received in February 2008. This submission included information on the pests associated with mangosteen crops in Indonesia, including the plant part affected, and the standard commercial production practices for fresh mangosteen fruit in Indonesia (IAQA 2008). Additional information on a number of pests was provided in 2009.

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[1] A pest is any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products.

On 4 June 2010, Biosecurity Australia (now DAFF Biosecurity) formally announced the commencement of this risk analysis, advising that it would be progressed as a non-regulated analysis of existing policy.

1.2.2 Scope

The scope of this non-regulated analysis is to consider the quarantine risk that may be associated with the importation of commercially produced fresh mangosteen fruit (*Garcinia mangostana* L.), free from trash, from Indonesia, for human consumption in Australia.

In this analysis, mangosteens are defined as fruit with the fruit stalk and calyx attached but not other plant parts (Figure 4). This analysis covers all commercially produced mangosteen fruit and the regions of Indonesia in which they are grown for export.

1.2.3 Existing policy

International policy

Import policy exists for fresh mangosteen fruit from Thailand (DAFF 2004b), and mangosteens have been imported from Thailand since 2004.

The import requirements for fresh mangosteen fruit from Thailand can be accessed at the AQIS Import Conditions database http://www.aqis.gov.au/icon.

DAFF Biosecurity has considered all pests previously identified in the *Mangosteen fruit from Thailand final import risk analysis report* (DAFF 2004b) and where relevant, taken this into account in the present assessment for mangosteen fruit from Indonesia.

Domestic arrangements

The Australian Government is responsible for regulating the movement of plants and plant products into and out of Australia. However, the state and territory governments are responsible for plant health controls within Australia. 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.

1.2.4 Contaminating pests

In addition to the pests of mangosteen fruit from Indonesia that are assessed in this non-regulated 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. DAFF Biosecurity considers these organisms to be contaminating pests that could pose sanitary and phytosanitary risks. These risks are addressed by existing operational procedures that require a 600 unit inspection of all consignments and investigation of any pest that may be of quarantine concern to Australia.

The risk of contaminating weed seeds is also addressed by the procedures detailed in section 5.3.

1.2.5 Consultation

On 4 June 2010, Biosecurity Australia notified stakeholders in Biosecurity Australia Advice (BAA) 2010/17 of the formal commencement of a non-regulated analysis of existing policy to consider a proposal to import fresh mangosteen fruit from Indonesia.

On 24 November 2011, DAFF Biosecurity provided a draft pest categorisation table for mangosteen fruit from Indonesia to the relevant state and territory government departments for their advance consideration, prior to the formal release of the draft report for the non-regulated analysis of existing policy.

The draft report was released on 9 March 2012 (BA 2012/05) for a period of 60 days for comment and consultation with stakeholders. The comment period ended on 8 May 2012. Two written submissions were received from stakeholders that are placed on the public file and the DAFF Biosecurity website. Both submissions were considered and material matters raised have been included in the present report.

2 Method for pest risk analysis

This section sets out the method used for the pest risk analysis (PRA) in this report. DAFF Biosecurity has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2007b) and ISPM 11: *Pest risk analysis for quarantine pests, including analysis of environmental risks and living modified organisms* (FAO 2004) 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 a pest should be regulated and the strength of any phytosanitary measures to be taken against it' (FAO 2009). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2009).

Quarantine risk consists of two major components: the probability 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, DAFF Biosecurity 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 spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO 2009).

A glossary of the terms used is provided at the back of this report.

The PRA was 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 quarantine concern and should be considered for risk analysis in relation to the identified PRA area.

Appendix A of this report lists the pests and diseases with the potential to be associated with exported mangosteen fruit produced using commercial production and packing procedures. The pests associated with the crop and the exported commodity was tabulated from information provided by Indonesia's National Plant Protection Organisation (NPPO) and literature and database searches.

For this PRA, 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 DAFF Biosecurity in other risk assessments and for which import policies already exist, a judgement based on the specific circumstances was made on 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, the previous risk assessment was taken into consideration when developing the new policy.

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 likelihood of associated potential economic consequences' (FAO 2009).

In this PRA, pest risk assessment was divided into the following interrelated processes:

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, as defined in ISPM 5: *Glossary of phytosanitary terms* (FAO 2009).

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 for the pests considered in this PRA are set out in columns 4-7 in Appendix A. The steps in the categorisation process are considered sequentially, with the assessment terminating with a 'Yes' in column 4 or the first 'No' in columns 5 or 6. The quarantine pests identified during pest 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 2004). A summary of this process is given below, followed by a description of the qualitative methodology used in this risk analysis.

Probability of entry

The probability of entry describes the probability 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 probability 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 Section 3. These practices are taken into consideration by DAFF Biosecurity when estimating the probability of entry.

For the purpose of considering the probability of entry, DAFF Biosecurity divides this step into two components:

- **Probability of importation**: the probability that a pest will arrive in Australia when a given commodity is imported.
- **Probability of distribution**: the probability 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 considered in the probability of importation 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 (e.g. bulk, packed)
- 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 (e.g. refrigeration) applied to consignments during transport and storage in the country of origin, and during transport to Australia.

Factors considered in the probability of distribution include:

- commercial procedures (e.g. 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 (e.g. for planting, processing or consumption)
- risks from by-products and waste.

Probability of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2009). In order to estimate the probability of establishment of a pest, reliable biological information (lifecycle, host range, epidemiology, survival, etc.) 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 probability of establishment.

Factors considered in the probability of establishment in the PRA area 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.

Probability of spread

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2009). The probability 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 probability 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 probability of spread.

Factors considered in the probability of spread 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 qualitative likelihoods for the probability of entry, establishment and spread

In its qualitative PRAs, DAFF Biosecurity uses the term 'likelihood' for the descriptors it uses for its estimates of probability of entry, establishment and spread. Qualitative 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). Descriptive definitions for these descriptors are given in Table 2.1. The standardised likelihood descriptors provide guidance to the risk analyst and promote consistency between different risk analyses.

Table 2.1 Nomenclature for qualitative likelihoods

Likelihood	Descriptive definition
High	The event would be very likely to occur
Moderate	The event would occur with an even probability
Low	The event would be unlikely to occur
Very low	The event would be very unlikely to occur
Extremely low	The event would be extremely unlikely to occur
Negligible	The event would almost certainly not occur

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.

For example, if the probability of importation is assigned a likelihood of ‘low’ and the probability of distribution is assigned a likelihood of ‘moderate’, then they are combined to give a likelihood of ‘low’ for the probability of entry. The likelihood for the probability of entry is then combined with the likelihood assigned to the probability of establishment (e.g. ‘high’) to give a likelihood for the probability of entry and establishment of ‘low’. The likelihood for the probability of entry and establishment is then combined with the likelihood assigned to the probability of spread (e.g. ‘very low’) to give the overall likelihood for the probability of entry, establishment and spread of ‘very low’. A working example is provided below;

P [importation] x *P* [distribution] = *P* [**entry**] e.g. **low x moderate = low**

P [entry] x *P* [establishment] = *P* [**EE**] e.g. **low x high = low**

P [**EE**] x [spread] = ***P* [EES]** e.g. **low x very low = very low**

Table 2.2 Matrix of rules for combining qualitative 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

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 time passes and the overall volume of trade increases.

DAFF Biosecurity 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.

The use of a one year volume of trade has been taken into account when setting up the matrix that is used to estimate the risk and therefore any policy based on this analysis does not simply apply to one year of trade. Policy decisions that are based on DAFF Biosecurity'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.

In assessing the volume of trade in this PRA, DAFF Biosecurity assumed that a substantial volume of trade will occur.

2.2.3 Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the likely 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 2009) and ISPM 11 (FAO 2004).

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, etc.
- 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)[2] using table 2.3[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 based on the magnitude of consequences at four geographic scales

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

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.

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[2] In earlier qualitative IRAs, 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-F has 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.

[3] The decision rules for determining the consequence impact score are presented in a simpler form in Table 2.3 from earlier IRAs, to make the table easier to use. The outcome of the decision rules is the same as the previous table and makes no difference to the final impact score.

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 above assessments 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 probability of entry, establishment and spread and the overall consequences of pest establishment and spread. Therefore, risk is the product of likelihood and consequence.

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (e.g. 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.

Table 2.5 Risk estimation matrix

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

2.2.5 Australia's appropriate level of protection (ALOP)

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. Australia's ALOP, 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 Australia's ALOP.

2.3 Stage 3: Pest risk management

Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks to achieve Australia's ALOP, 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 exceeds Australia's ALOP, 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 Australia's ALOP. The effectiveness of any proposed phytosanitary measures (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure it reduces the restricted risk for the relevant pest or pests to meet Australia's ALOP.

ISPM 11 (FAO 2004) 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 probability of entry of the pest.

Examples given of measures commonly applied to traded commodities include:

- options for consignments – e.g., 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 – e.g., 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 – e.g., pest-free area, pest-free place of production or pest-free production site
- options for other types of pathways – e.g., consider natural spread, measures for human travellers and their baggage, cleaning or disinfestations of contaminated machinery
- options within the importing country – e.g., 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 risk exceeds Australia's ALOP. These are presented in the 'Pest Risk Management' section of this report.

3 Indonesia’s commercial production practices for mangosteen fruit

This chapter provides information on the pre-harvest, harvest and post-harvest practices in Indonesia for the production of fresh mangosteen fruit for export. The practices described in this section are considered to be standard for export of mangosteen fruit in Indonesia, and DAFF Biosecurity has taken them into consideration when estimating the unrestricted risk of pests that may be associated with the import of this commodity. The export capability of Indonesia is also outlined.

3.1 Assumptions used in estimating unrestricted risk

Indonesia provided Australia with information on the standard commercial practices used in the production of mangosteens in different regions and for all commercially produced mangosteen varieties in Indonesia. 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.

DAFF Biosecurity visited mangosteen production areas in West Java from 6–9 September 2011, to verify the pest status and observe the harvest, processing and packing procedures for export of mangosteen fruit. DAFF Biosecurity’s observations and additional information provided during the visit confirmed the production and processing procedures described in this chapter as standard commercial production practices for mangosteen fruit for export.

In estimating the likelihood of pest introduction it was assumed that the pre-harvest, harvest and post-harvest production practices for mangosteen fruit as described in this chapter are implemented for all regions and for all mangosteen varieties within the scope of this analysis. Where a specific practice described in this chapter is not taken into account to estimate the unrestricted risk, it is clearly identified and explained in Chapter 4.

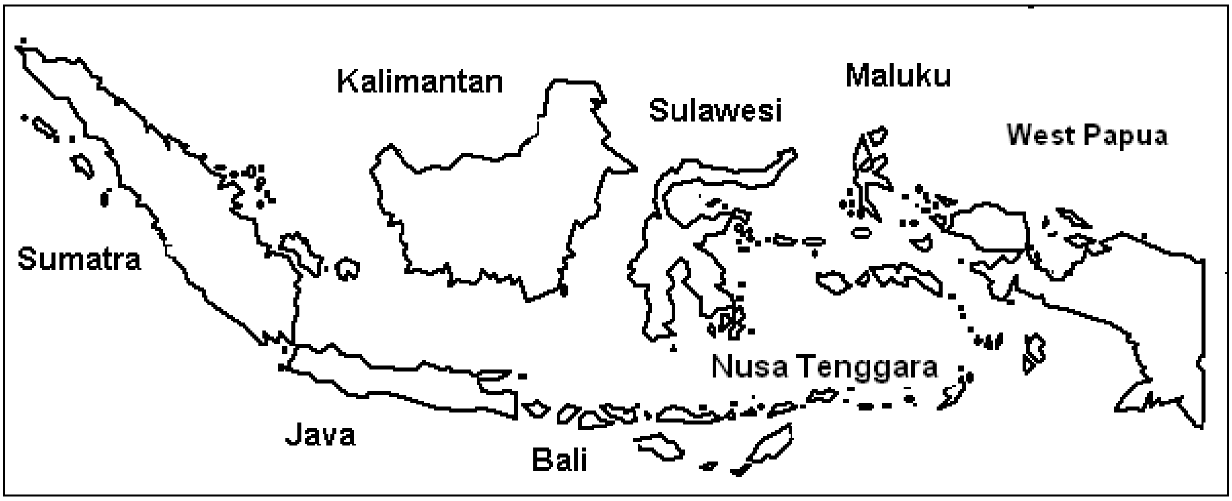

Figure 5 Map of Indonesia[4]

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[4] Map modified from http://www.enchantedlearning.com/asia/indonesia/outlinemap/ and http://www.seasite.niu.edu/indonesian/indonesian-map/indo-map-fs.htm.

3.2 Climate in production areas

Mangosteens are grown across all of Indonesia, with the main production areas scattered across Sumatra, Java, Bali and Nusa Tenggara (PHTRI 2010).

Indonesia's largest mangosteen production area is the province of West Java, followed by South Sumatra. Other production provinces of note include East Java, Central Java and West Sumatra (Mansyah *et al.* 2010).

Indonesia lies close to the equator, which means that the climate is almost entirely tropical (hot and humid). The temperature remains fairly constant throughout the year, with the coastal plains averaging 28 °C, the inland and mountain ranges averaging 26 °C and the higher mountain regions, 23 °C (Frederick and Worden 1993). Seasonal variation is dominated by precipitation.

Indonesia's climate is divided into rainy and dry season. The extreme variations in rainfall are linked with the monsoons. The northwestern monsoons bring the rainy season from October to April, while the southern and eastern monsoons bring the dry weather that occurs from May to September. The dry season does not mean there is no rain, but less rain with tropical showers occurring in the afternoons.

In general, the western and northern parts of Indonesia experience the most precipitation. Western Sumatra, Java, Bali, the interiors of Kalimantan, Sulawesi and West Papua are the wettest regions of Indonesia, with the annual rainfall measuring more than 2000 mm. The islands closer to Australia, Nusa Tenggara and the eastern tip of Java, tend to be dryer with some areas experiencing less than 1000 mm per year (Weatheronline 2011).

Rainfall in Indonesia also varies with topography. In the lowland areas of Indonesia, the annual rainfall averages 1800–3200 mm and increases with elevation to more than 6000 mm. In West Java, the main mangosteen production area of Indonesia, the average rainfall along the north coast is 2000 mm per year, and in the mountainous areas, rainfall ranges from 3000 to 5000 mm per year.

The rainfall in Sumatra, the second largest mangosteen production area in Indonesia, also varies across the island. The wettest part of Sumatra is the narrow west coast plain and the west foothills of the Bukit Barians, averaging 4000 mm per year and rising to 6000 mm per year in the town of Bengkulu. Rainfall is lower in Central, East and North Sumatra averaging 2500 mm to 3000 mm per year (Eliot *et al.* 2001).

3.3 Pre-harvest

3.3.1 Cultivars

Mangosteen is an apomictic plant and propagation is by apomictic seed, where the embryo and seed forms without fertilisation (Sobir and Poerwanto 2007). Thus, mangosteen trees are essentially clonal, which means that the offspring is genetically identical to the mother plant (Mansyah *et al.* 2010). Based on this assumption, there is only one variety of cultivated mangosteen (Horn 1940; Sobir and Poerwanto 2007; Mansyah *et al.* 2010). However, distinct variations in morphological characters can be observed across Indonesia and Southeast Asia, where mangosteens are grown.

Earlier studies suggested that variation of mangosteen plants between regions were due to differences in environmental conditions (Horn 1940). However, recent studies using DNA markers have confirmed genetic variability among the mangosteen population and *Garcinia* spp. (Sobir and Poerwanto 2007; Sobir *et al.* 2011). These studies suggest that mangosteen did not originate from a single hybridisation of its ancestral sexual parents (*G. malaccensis* and *G. hombrioniana*) as previously thought. Southeast Asia, including Indonesia, is a center of diversity for *Garcinia*, and this would most likely explain the variation among mangosteen populations (Sobir *et al.* 2011).

Mansyah *et al*. (2010) identified eleven morphological characteristics that can be used to distinguish mangosteen varieties in Indonesia, these being: canopy shape; leaf area; fruit weight; mature leaf colour; number of flowers and fruit per cluster; fruit shape; fruit base shape; stigma lobe shape, size and thickness; number of fruit segments; pedicel length; and rind thickness.

There are a number of identified mangosteen varieties that are grown in specific regions of Indonesia: Kaligesing, Wanayasa, Puspahiang, Bogor Raya, Ratu Kamang, Ratu Tembilahan, Marel, Lingsar and Malinau (IAQA 2010).

Puspahiang, Wanayasa and Bogor Raya are the three main mangosteen varieties commercially grown in Indonesia. The morphological characteristics for these varieties are shown in Table 3.1. The Kaligesing variety is also favoured across Indonesia as it is resistant against fruit borer and fusarium wilt (IAQA 2011).

Table 3.1 Characteristics of common mangosteen varieties in Indonesia

Trait	Varieties		
	Puspahiang	Wanayasa	Raya
Fruit shape	Oval	Round	Spherical round
Fruit size	Height: 41–61 mm Diameter: 44–64 mm	Height: 30–45 mm Diameter: 45–55 mm	Height: 30–45 mm Diameter: 45–50 mm
Skin colour	Dark violet	Red violet	Red violet
Skin thickness	Medium	3–5 mm	6–9 mm
Flesh colour	White	Milk white	Snow white
Flesh texture	Soft	Soft	Soft not fibrous
Flesh taste	Fresh sweet	Fresh sweet	Sweet acid
Sugar content	15.0 °Bx	17.75 °Bx	18.65 °Bx
Weight per fruit	50–131 g	90–110 g	75–94 g
Growing region	Tasikmalaya District	Purwakarta District	Bogor and Sukabumi District
Harvest season	September to April	December to April	October to February

3.3.2 Cultivation practices

Mangosteen production in Indonesia is usually of small scale, and trees are often grown in backyard gardens and on steep slopes. Mangosteens are usually grown as an opportunistic crop and co-cultivated with other crops such as banana (*Musa* spp.), durian (*Durio zibethinus*), coconut (*Cocos nucifera*), papaya (*Carica papaya*), cassava (*Manihot esculenta*), and duku (*Lansium domesticum*).

Mangosteens are propagated from seed or by vegetative methods such as grafting and budding. New mangosteen varieties and planting material are propagated from certified seeds registered with Indonesia's Department of Agriculture (IAQA 2008). Vegetative material used for new plantings is generally one to two years of age and around 30 cm high. Mangosteen trees are slow-growing, and it takes a minimum of six years for the tree to reach maturity and commence bearing fruit.

Orchards usually consist of one mangosteen variety, and young trees are commonly planted at the beginning of the rainy season. Plants are typically spaced at a distance of 10 m by 10 m with other plants such as banana and coconut planted in between to provide shade. On steep land, plots are terraced (Figure 6). At the base of each terrace is a trough to collect fallen leaves and debris during the fruiting and harvest period.

Figure 6 **Terrace planting and trough**

There are no specific horticultural techniques required to produce mangosteens. Trees require little care until flowering begins when the tree reaches 6 to10 years of age.

Mangosteen trees require adequate moisture and good drainage, especially during the early stage of establishment. Mulch is spread around the base of young trees to keep the soil moist. The mulch also acts as an organic fertiliser, enriching the soil with nutrients. As the tree matures, the ground is mulched naturally by falling leaves and debris from surrounding plants. The ground is cleared of excess leaves every two months or so, and leaves are burned. During the fruiting and harvest period, the orchard is cleared of debris more regularly.

Trees are lightly pruned before flowering to enable more sunlight to penetrate. Trees are again pruned after harvesting to promote new growth. Growers prune old, diseased and damaged branches, branches that touch the soil and suckers that grow up from the base of the trunk.

Weeds are controlled manually or naturally through mulching. Chemical sprays are not a common practice for the management of weeds.

Irrigation is not required as the natural rainfall provides enough water for the plants. Additionally, shade from surrounding vegetation prevents water loss and mulching keeps the ground moist.

3.3.3 Pest management

The following information on pest and disease management was provided by Indonesia (IAQA 2010). All export mangosteen fruit are produced in orchards registered by Indonesia's Department of Agriculture which are certified to operate in accordance with Indonesia's farm certification scheme for Good Agricultural Practice (GAP) (IAQA 2011).

Each registered orchard follows the national guidelines developed by the Directorate of Horticulture Crop Protection and the Directorate of Food Crop Protection, covering pest monitoring and surveillance. The two directorates are responsible for instructing and overseeing the implementation of these guidelines. The pest monitoring and surveillance plan ensures orchards are monitored and inspected for pest and diseases by trained pest observers. Regional and central Food Crop and Horticulture Protection Centres are responsible for maintaining the inspection records and associated laboratories manage the diagnostics of arthropods and pathogens.

The Integrated Pest Management (IPM) program used by mangosteen growers includes a range of agronomic practices to reduce the number of arthropod and pathogen pests, namely mulching, pruning, fruit thinning, and field sanitisation practices such as collecting fallen leaves, weeding and 'smoke-sanitising' the orchard.

Only a relatively small number of pests and diseases are associated with mangosteen production. Pesticides are not commonly used to control pests and diseases, but rather pest management measures such as orchard hygiene and pruning. Table 3.2 outlines the pest control measures for mangosteen production as provided by Indonesia (IAQA 2010).

Table 3.2 Pest and disease control practices for mangosteen production in Indonesia (IAQA 2010)

Pest/disease	Common name	Indonesia's control measures
Arthropod		
Tetranychus spp.	Spider mites	Pruning canopy to reduce density and overlapping; fruit thinning; field hygiene; natural enemies (Coccinellidae, Chrysophidae)
Icerya seychellarum	Seychelles scale	Pruning canopy to reduce density and overlapping; fruit thinning; field hygiene
Exallomochlus hispidus	Cocoa mealybug	Pruning canopy to reduce density and overlapping; fruit thinning
Helopeltis antonii	Leaf and fruit sucker	Pruning canopy to reduce density and overlapping; removing heavily infested plants; natural enemies – praying mantises, spiders and ladybugs
Hyposidra talaca	Leaf caterpillar	Field hygiene; trimming and destroying attacked leaves
Phyllocnistis citrella	Citrus leaf miner	Trimming and destroying attacked leaves; natural enemy – *Ageniaspis* sp.
Scirtothrips dorsalis	Chilli thrips	Pruning canopy to reduce density and overlapping; field hygiene
Pathogen		
Corticium salmonicolor	Pink disease	Pruning canopy to reduce density and overlapping; removing branches 30 cm below the rotted part of the bark; applying bordeaux porridge (*carbolineum plantarum*) to affected branch
Colletotrichum gloeosporioides	Fruit rot	Field hygiene; good post-harvest handling practices
Pellicularia koleroga	Leaf brown spot	Pruning canopy to reduce density and overlapping; removing diseased leaves and twigs; field hygiene
Pestalotiopsis palmarum	Leaf spot	Pruning canopy to reduce density; removing dead part; pruning sick leaves; field hygiene

3.4 Harvesting and handling procedures

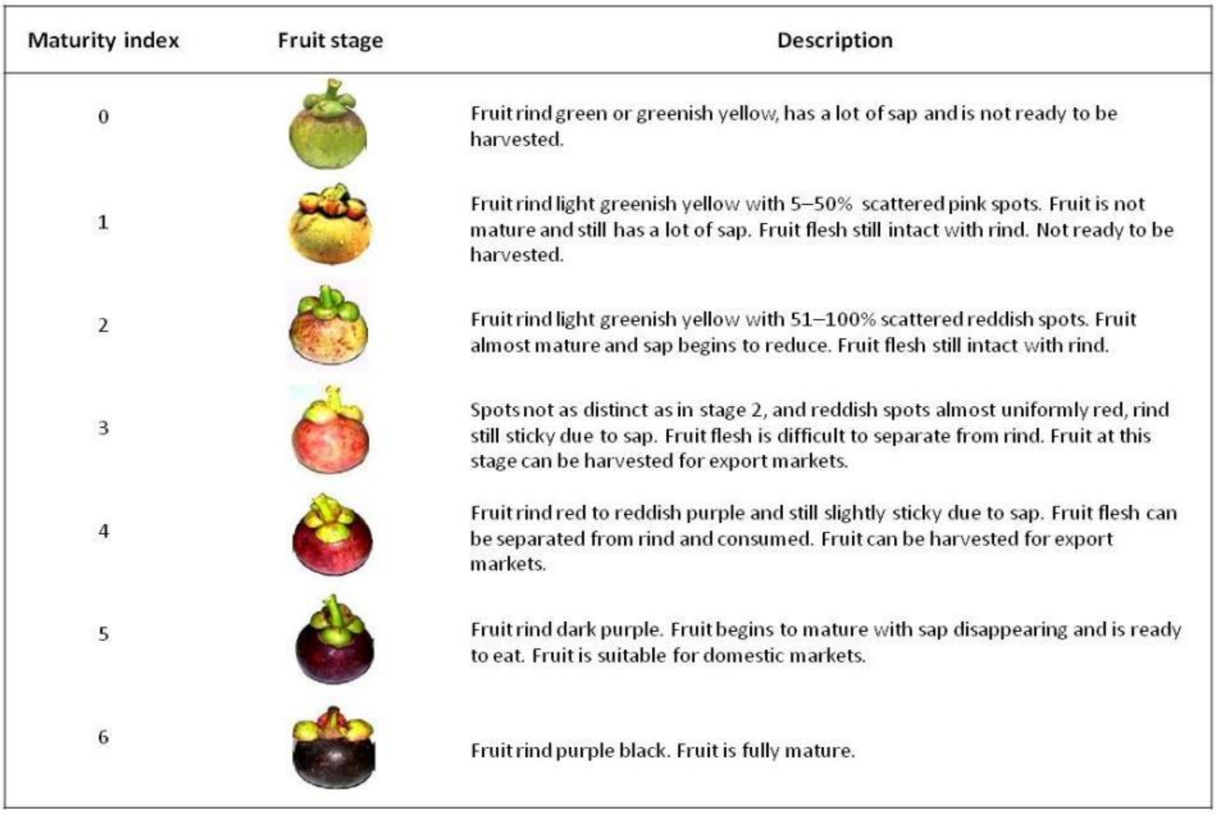
Indonesian mangosteens are harvested almost all year round, with November through to February as the peak harvest period (IAQA 2011). The harvest period varies across the islands of Indonesia. The main harvest period for the main mangosteen production regions of Indonesia is outlined in Table 3.3.

Table 3.3 Harvest period for Indonesia's main mangosteen production regions (SADI-ACIAR 2008)

States	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
West Sumatra								▨	▨	▨	▨	
Medan (North Sumatra)									▨	▨	▨	▨
Central Java	▨	▨									▨	▨
East Java	▨	▨	▨									▨
Bali	▨	▨	▨									▨
Lombok (Nusa Tenggara)	▨	▨	▨									▨
West Java		▨	▨	▨	▨							

Mangosteen fruit are harvested from 103 days after flowering. Mangosteens ripen at different rates; therefore harvested fruit from an individual tree may be at various maturity levels. Indonesian mangosteens are generally harvested when the fruit is pink to red in colour (maturity index 4 or 5, see table 3.4) as this is preferred for domestic and current export markets. Indonesia has indicated that undamaged mangosteen fruit at maturity index 2–3 would be exported to Australia. These fruit are considered to be a conditional non-host for fruit flies.

Table 3.4 Indonesia's mangosteen maturity index (IAQA 2011)



Maturity index	Fruit stage	Description
0		Fruit rind green or greenish yellow, has a lot of sap and is not ready to be harvested.
1		Fruit rind light greenish yellow with 5–50% scattered pink spots. Fruit is not mature and still has a lot of sap. Fruit flesh still intact with rind. Not ready to be harvested.
2		Fruit rind light greenish yellow with 51–100% scattered reddish spots. Fruit almost mature and sap begins to reduce. Fruit flesh still intact with rind.
3		Spots not as distinct as in stage 2, and reddish spots almost uniformly red, rind still sticky due to sap. Fruit flesh is difficult to separate from rind. Fruit at this stage can be harvested for export markets.
4		Fruit rind red to reddish purple and still slightly sticky due to sap. Fruit flesh can be separated from rind and consumed. Fruit can be harvested for export markets.
5		Fruit rind dark purple. Fruit begins to mature with sap disappearing and is ready to eat. Fruit is suitable for domestic markets.
6		Fruit rind purple black. Fruit is fully mature.

Harvesting is done manually using long poles which have a cloth bag attached to catch the fruit, or are forked at the end (Figure 7).

Figure 7 **Different types of harvesting poles. Pole with attached bag (left) and forked pole (right)**

Generally, a farmer will climb the tree and use the pole to pick the fruit which falls into the attached bag. The harvested fruit is then transferred into bamboo baskets lined with banana leaves (Figure 8) and taken to the collection house for initial sorting.

Figure 8 **Harvesting of mangosteen fruit** (left) and bamboo basket lined with banana leaves (right)

3.5 Post-harvest

3.5.1 Collection house

Harvested fruit are taken to a collection house which is located close to the orchards. Collection houses are responsible for receiving fruit from registered farmer groups (one group equals about 50 farmers or orchards) from a defined production area.

The collection house usually consists of an open shed or brick house with a concrete floor. Here, fruit harvested from export-registered farms is separated from that of non-registered farms.

The fruit is pre-sorted into colour-coded crates. Blue or green creates are used to identify fruit from registered export orchards (Figure 9). All damaged fruit and fruit that does not meet the export maturity index requirement are removed. Crates are weighed and labelled with a 4-digit collection house code, GAP registration number and 5-digit production number. The production number identifies what farm the fruit was sourced from, harvest date, volume and destination.

Figure 9 **Initial sorting of mangosteen fruit at the collection house**

There are no storage facilities at the collection house, and the harvested mangosteen fruit are transported daily to the packing house in enclosed trucks. Transport may take up to 3–4 hours.

3.5.2 Packing house

At the time of publication, Indonesia’s Agricultural Quarantine Agency (IAQA) has identified four packing houses, all located in West Java province, which have been registered under the Directorate General of Processing and Marketing of Agricultural Products and are certified to follow Good Handling Practices (GHP) and able to process mangosteen fruit for the export market.

Sorting and initial grading

Harvested mangosteen fruit are sorted and graded according to size, uniformity, maturity level and quality of fruit. The fruit is graded into three classes (IAQA 2011), these being:

- Super I – Fruit stalk is fresh green in colour, calyx is complete and bright green in colour, and fruit skin is free of damage
- Super II – Fruit stalk is pale green in colour, calyx is incomplete and green with some brown colour, and 30% of fruit skin shows scratch damage
- Super III – Fruit stalk is dull green in colour, calyx is incomplete and green with some brown colour, and 30–50% of fruit skin shows scratch damage

Any damaged or defective fruit are downgraded and removed by the packing house staff before packing for export. Indonesia has advised that mangosteens classified as ’Super I and II’ would be exported to Australia.

Cleaning and final grading

Each individual mangosteen is manually cleaned with air pressure guns to remove any debris or insects hidden under the calyx of the fruit. The individual cleaning is conducted by a team of workers over sticky traps or water baths to collect the material and prevent contamination. Following the air pressure cleaning, mangosteens are individually brushed to remove any pests adhering to the fruit.

Any fruit damaged during the cleaning process is removed and the fruit is then sorted by weight into further classes, depending on export destination and market requirements.

Packaging and storage

Mangosteens are generally packed into 8 kg plastic crates lined with paper. A lightly wet foam sheet is placed on top of each crate to maintain the moisture level, and the crate is sealed. However, the packaging material may differ according to the importing country’s requirements.

The plastic crates are clearly labelled with the packing house and farm registration number, product quality and class, packing date and export destination for quality assurance and quarantine trace-back purposes.

Packed and sealed crates are stacked (maximum 12 crates high) into cold rooms, where they are stored for a short period of time at ~ 13 °C. Fruit for domestic and export markets are stored separately.

3.5.3 Phytosanitary inspection

Packed mangosteen fruit is inspected in designated quarantine inspection facilities by IAQA inspectors to meet the phytosanitary requirements of the importing country. Only mangosteens that meet the requirements of the importing country are issued with a phytosanitary certificate for export.

3.5.4 Loading and transportation

Packed fruit is loaded from the cold storage facility into closed refrigerated trucks or containers and sealed. Refrigerated containers are transported directly from the packing house to the port or airport. Although airfreight is the preferred means of transport, mangosteens may also be exported to Australia by sea in refrigerated shipping containers.

The transportation of mangosteen fruit from Indonesia to Australia, i.e. from packing house to arrival, may take upto 7 days by air and 16–19 days by sea (Australia Trade and Shipping 2012).

Figure 10 summarises the post-harvest steps (collection house, packing house and distribution) for mangosteen fruit grown in Indonesia for export (adapted from IAQA 2011).

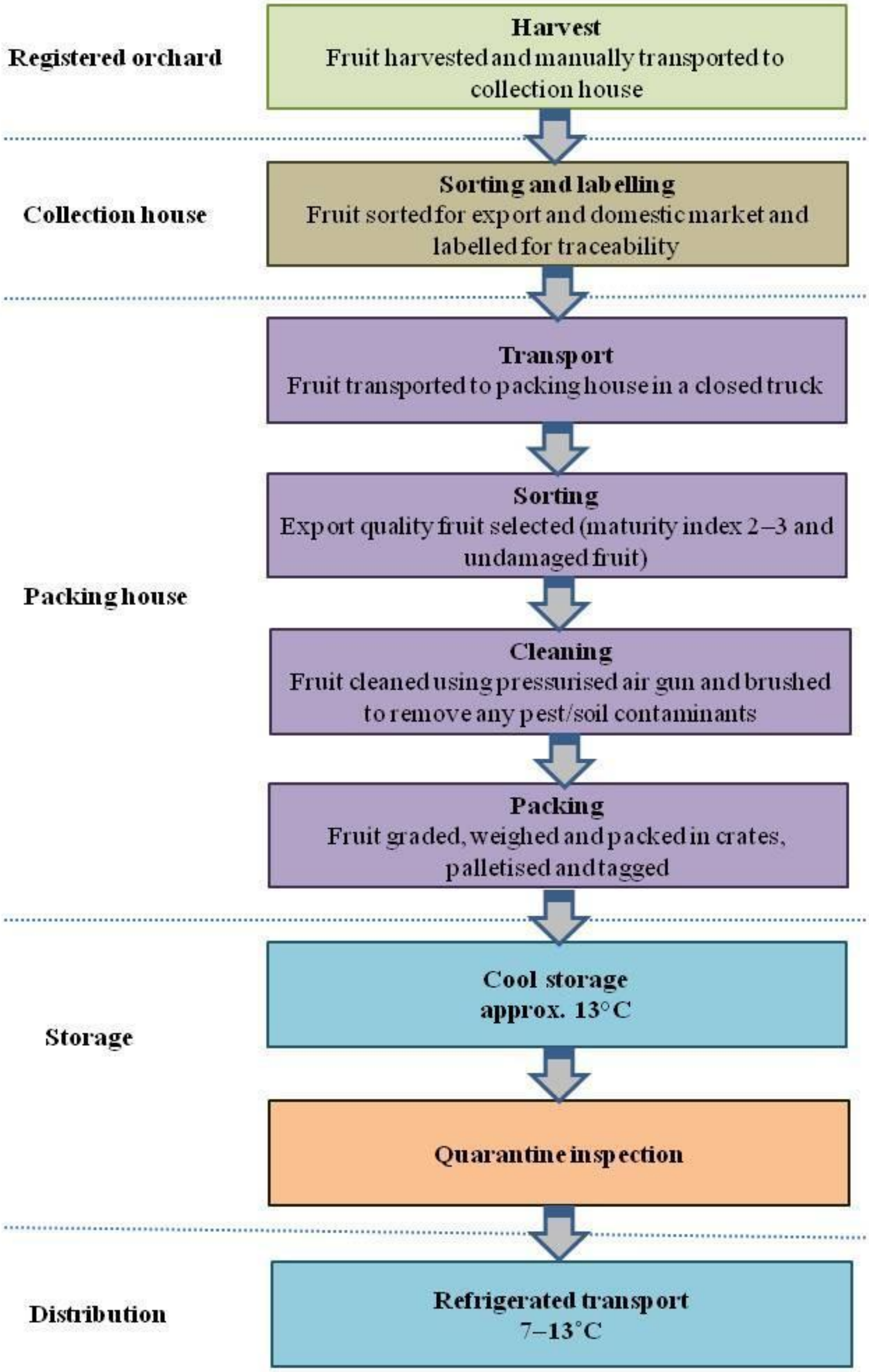


Figure 10 **Summary of orchard and post-harvest steps for mangosteen fruit grown in Indonesia for export**

3.6 Production and export statistics

In 2010, Indonesia produced around 84 500 tonnes of mangosteens, with the majority of production in West Java. East Java, North Sumatra and provinces along the south-western coast of Sumatra (IAQA 2011). Of these, only 2450 tonnes of mangosteens was exported. The main export markets are China, the Middle East and Europe (IAQA 2011). However, these markets do not require specific phytosanitary measures for the importation of mangosteens from Indonesia.

The Indonesian government has advised that initially, around 2–4 tonnes of mangosteens are likely to be exported annually to Australia. However, this amount may increase in following years.

4 Pest risk assessments for quarantine pests

Quarantine pests associated with fresh mangosteen fruit from Indonesia are identified in the pest categorisation process (Appendix A). This chapter assesses the probability of the entry, establishment and spread of these pests and the likelihood of associated potential economic, including environmental, consequences.

Pest categorisation identified 33 quarantine pests associated with mangosteen fruit from Indonesia. Of these, 29 pests are of national concern and four are of regional concern. Table 4.1 identifies these quarantine pests, and full details of the pest categorisation are given in Appendix A. Additional quarantine pest data are given in Appendix B.

Assessments of risks associated with these pests are presented in this chapter. Pests are listed or grouped according to their taxonomic classification, consistent with Appendix A and Appendix B.

Pest risk assessments were completed to determine whether the risk posed by each pest exceeds Australia's ALOP and thus whether phytosanitary measures are required to manage the risk. Pest risk assessments already exist for some of the pests considered here as they have been assessed previously by DAFF Biosecurity. For these pests, the likelihood of entry (importation and/or distribution) is re-assessed due to the differences in the commodity and/or country assessed. This type of assessment is reflected in the introduction and layout of the risk assessments that follow. In this report, the superscript 'EP' (existing policy) is used for pests that have previously been assessed and where a policy already exists. Some pests identified in this assessment have been recorded in some regions of Australia, and due to interstate quarantine regulations are considered pests of regional concern. These organisms are identified with a superscript, such as 'WA' (Western Australia), for the state for which the regional pest status is considered.

Mangosteens harvested, packed, stored and transported for export to Australia may need to travel variable distances to ports. Depending on the port of departure and arrival it could take up to three weeks for general sea freight from Indonesia to Australia. Mangosteen fruit could also potentially be air-freighted from Indonesia to Australia within about a week from harvest. While the unrestricted risk assessments undertaken in this risk analysis do not impose any mandatory measures during storage and transport, common commercial practices may impact on the survival of some pests. If these conditions are applied to all consignments for a minimum period of time, then they could be considered as part of the unrestricted risk assessment.

Table 4.1 Quarantine pests for mangosteen fruit from Indonesia

Pest	Common name
Spider mites [Prostigmata: Tetranychidae]	
Tetranychus spp.	Spider mites
Weevils [Coleoptera: Curculionidae]	
Curculio sp.	
Fruit flies [Diptera: Tephritidae]	
Bactrocera carambolae Drew & Hancock, 1994 $^{\mathbf{EP}}$	Carambola fruit fly
Bactrocera papayae Drew & Hancock, 1994 $^{\mathbf{EP}}$	Papaya fruit fly
Soft scales [Hemiptera: Coccidae]	
Drepanococcus chiton (Green, 1909) ^{EP}	Soft scale
Armoured scales [Hemiptera: Diaspididae]	
Diaspis boisduvalii Signoret, 1869 ^{WA}	Boisduval scale
Ischnaspis longirostris (Signoret, 1882) $^{EP, WA}$	Black thread scale
Pseudaonidia trilobitiformis (Green, 1896) $^{EP, WA}$	Trilobite scale
Mealybugs [Hemiptera: Pseudococcidae]	
Dysmicoccus lepelleyi (Betrem, 1937)	Annona mealybug
Exallomochlus hispidus (Morrison, 1921)	Cocoa mealybug
Hordeolicoccus heterotrichus (Williams, 2004)	Citrus mealybug
Paracoccus interceptus Lit, 1997	Intercepted mealybug
Paraputo odontomachi (Takahashi, 1951)	
Planococcus lilacinus (Cockerell, 1905) ^{EP}	Coffee mealybug
Planococcus minor (Maskell, 1897) $^{EP, WA}$	Pacific mealybug
Pseudococcus aurantiacus Williams, 2004	Orange-coloured mealybug
Pseudococcus baliteus Lit, 1994	Aerial root mealybug
Pseudococcus cryptus Hempel, 1918 ^{EP}	Cryptic mealybug
Rastrococcus spinosus (Robinson, 1918) ^{EP}	Philippine mango mealybug
Ants [Hymenoptera: Formicidae]	
Camponotus sp.	
Cardiocondyla sp.	
Crematogaster sp.	
Dolichoderus sp. $^{\mathbf{EP}}$	
Iridomyrmex sp.	
Monomorium sp.	
Paratrechina sp.	
Pheidole sp.	
Plagiolepis sp.	
Polyrhachis sp.	
Tapinoma sp.	
Technomyrmex sp. $^{\mathbf{EP}}$	
Tetramorium sp.	
Wasmannia auropunctata ^{EP} (Roger, 1863)	Little fire ant

4.1 Spider mites [Prostigmata: Tetranychidae]

***Tetranychus* spp.** $^{\mathrm{EP}}$

Tetranychus spp. belong to the spider mite family, Tetranychidae. Spider mites are given this name due to their habit of spinning protective silken webbing on plants (Zhang 2003).

The genus *Tetranychus* is widely distributed throughout the world (Bolland *et al.* 1998). It comprises of more than 120 species, but only 11 of these are known to be present in Australia (Flechtmann and Knihinicki 2002). A number of *Tetranychus* spp. are endemic to the Oriental region (Bolland *et al.* 1998) and may also be present in Indonesia. *Tetranychus* spp. that are known to be present in Indonesia but not in Australia include *T. piercei, T. truncatus* and *T. kanzawai,* which is not present in Western Australia (Waterhouse 1993; Migeon and Dorkeld 2010).

Most spider mites are polyphagous, that is, they infest a wide range of host plants, while others are host-specific (Gutierrez and Helle 1985). *Tetranychus* spp. are of economic significance to many horticultural crops including banana, papaya, cassava, peach, citrus, mulberry, bean, eggplant, sweet potato, garlic, tea, oil palm and cotton (Jeppson *et al.* 1975; Corpuz-Raros 1989; Walter 2006). *Tetranychus* spp. are a minor pest of mangosteen in Indonesia (IAQA 2008).

Tetranychus spp. feed on the undersurface of leaves but will move out to other parts of the host plant when populations become high (Jeppson *et al.* 1975). They feed by inserting their mouthparts into the plant tissue and remove the cell contents (Jeppson *et al.* 1975). A few spider mite species feed on the fruits of horticulture crops, resulting in discoloration and the downgrading of fruit (Jeppson *et al.* 1975). *Tetranychus* spp. can infest the flowers and damage the fruit surface of mangosteens (Yaacob and Tindall 1995).

Spider mites develop rapidly, and their overall life cycle is relatively short (Huffaker *et al.* 1969). There are five developmental stages: egg, larva, two nymphal stages (protonymph and deutonymph) and an adult stage (Jeppson *et al.* 1975). The time required to complete a lifecycle from egg to adult varies from 6–10 days or more depending on the species, temperature, host plant, humidity and other environmental factors (Crooker 1985). In warm tropical climates, spider mites continue to reproduce throughout the year (Jeppson *et al.* 1975). A generation may live for only 15–20 days (Gutierrez 1978). In colder climates, *Tetranychus* spp. survive the winter temperatures by entering an inactive state or diapause stage, commonly as fertilised females (Huffaker *et al.* 1969; Jeppson *et al.* 1975). Diapausing females seek shelter in cracks and crevices or under groundcover, and when the warm weather returns they become active and start feeding again (Jeppson *et al.* 1975).

All *Tetranychus* spp. are capable of reproducing sexually or parthenogenetically, that is without a mate (Helle and Pijnacker 1985). Unfertilised eggs develop into males, while fertilised eggs produce both males and females (Helle and Pijnacker 1985; Zhang 2003). Spider mites tend to deposit their eggs near the midribs of the leaves of host plants (Jeppson *et al.* 1975). Eggs are small ranging from 0.110–0.150 mm in size (Crooker 1985). Total egg production varies from 10–150 or more, depending on species, temperature, humidity, and host plant (Crooker 1985); with most of the eggs produced within a few days of the first egg (Zhang 2003).

The risk scenario of concern for *Tetranychus* spp. is the presence of eggs, nymphs or adults on imported mangosteen fruit.

This pest risk assessment is for an unidentified *Tetranychus* species. *Tetranychus* species have been assessed in the existing import policies for stone fruit from the USA (Biosecurity Australia 2010), bananas from the Philippines (Biosecurity Australia 2008) and table grapes from China and Korea (Biosecurity Australia 2011a; Biosecurity Australia 2011b). The assessment of *Tetranychus* spp. presented here builds on these previous assessments.

Differences in the commodity, horticultural practices, climatic conditions and prevalence of *Tetranychus* spp. between previous export areas (USA, Philippines, China and Korea) and Indonesia make it necessary to reassess the likelihood that *Tetranychus* sp. will be imported into and distributed within Australia with mangosteen fruit from Indonesia.

The probability of establishment and spread of *Tetranychus* spp. in Australia and the consequences they may cause will be comparable for any commodity from which these species are imported into Australia, as these probabilities 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 risk ratings for establishment, spread and consequences, as set out for a *Tetranychus* species, *T. kanzawai* in the table grapes from China and Korea import risk analysis reports (Biosecurity Australia 2011a; Biosecurity Australia 2011b), will be adopted for this assessment.

4.1.1 Reassessment of probability of entry

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

Reassessment of probability of importation

The likelihood that *Tetranychus* spp. will arrive in Australia with the importation of mangosteen fruit from Indonesia is: **HIGH**.

Supporting information for this assessment is provided below:

- *Tetranychus* spp. are distributed worldwide (Bolland *et al.* 1998). Of the genus, *T. truncatus*, *T. piercei*, *T. kanzawai*, *T. cinnabarinus*, *T. lombardinii* and *T. urticae* are recorded as being present in Indonesia (Waterhouse 1993; Migeon and Dorkeld 2010). However, there are a number of *Tetranychus* species endemic to the Oriental region (Bolland *et al.* 1998) that may also be present in Indonesia.
- *Tetranychus* spp. are polyphagous (Bolland *et al.* 1998). In Indonesia, *Tetranychus* spp. are mainly a pest of tea and cassava (Hartini and Saim 2005), and are considered a minor pest of mangosteen (IAQA 2008).
- Spider mites are primarily a pest found on the leaves of host plants and both feed and lay eggs on the leaves (Jeppson *et al.* 1975). *Tetranychus* spp. feed on the leaves of mangosteens in Indonesia resulting in leaf curl (IAQA 2008).
- Spider mites are highly mobile and have the capacity to move onto all parts of the plant, including the fruit. *Tetranychus* spp. have been reported to cause damage to the fruit surface of mangosteens (Yaacob and Tindall 1995).

- The life cycle of spider mites depends on the species and environmental factors. In warm tropical climates, spider mites are capable of reproducing all year round (Yaacob and Tindall 1995). Therefore, *Tetranychus* spp. are likely to be present during harvest.
- Spider mites are very small, with the adult female ranging from 0.3–0.5 mm in length (Gutierrez 1978) and the males being even smaller (Kennedy and Smitley 1985). The small size of spider mites and their eggs (0.11–0.15 mm in diameter) may make them difficult to detect, especially at low population levels or when they are under the calyx of the fruit. Therefore, the sorting, grading and packing process may not remove them effectively from the export pathway.
- The brushing process would likely dislodge any mobile spider mites present on the surface of the fruit. However, spider mites have a tendency to live and deposit their eggs in secluded places (Jeppson *et al.* 1975) and the brushing process may not remove spider mites and/or eggs located under the calyx of the mangosteen fruit.
- *Tetranychus* spp. overwinter as fertilised females (Huffaker *et al.* 1969; Jeppson *et al.* 1975) and are likely to survive cold storage and transportation to Australia.

The small size, cold tolerance, presence of spider mites and their eggs under the calyx and host status support a likelihood estimate for importation of ‘high’.

Reassessment of probability of distribution

The likelihood that *Tetranychus* spp. will be distributed within Australia in a viable state as a result of the processing, sale or disposal of mangosteen fruit from Indonesia and subsequently transfer to a susceptible part of a host is: **MODERATE**.

Supporting information for this assessment is provided below:

- Mangosteen fruit may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- *Tetranychus* spp. eggs, nymphs and adults may remain on the fruit during retail distribution. The unconsumed parts of the fruit, especially the skin and calyx, are likely to end up as fruit waste, which may further aid distribution of viable mites. Disposal of infested fruit waste is likely to be by commercial or domestic rubbish systems, or where the fruit is consumed. Some fruit waste may be disposed of in the home garden which provides an opportunity for *Tetranychus* sp. to transfer to susceptible hosts in the vicinity.
- *Tetranychus* spp. have a wide host range including mangosteen (for a comprehensive list of horticultural hosts, see Appendix B). Ornamentals, flowering plants and grasses are also hosts of *Tetranychus* spp. (Bolland *et al.* 1998). Host plants are widely available in Australia.
- Spider mites disperse predominantly within and between host plants through crawling (Kennedy and Smitley 1985). Adult female spider mites can also be carried on air currents. While there is potential for long range transport on wind currents, aerial dispersal is generally initiated at high population densities and is entirely passive once airborne (Kennedy and Smitley 1985). Most spider mites fall out of the air currents shortly after they are carried aloft (Kennedy and Smitley 1985). The probability of spider mites on discarded mangosteen fruit locating a suitable host would be reduced when the short dispersal range is considered.

The possibility of dispersal near suitable hosts and the wide availability of hosts, moderated by the short dispersal range, support a likelihood estimate for distribution of 'moderate'.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probabilities of importation and of distribution using the matrix of rules shown in Table 2.2.

The likelihood that *Tetranychus* spp. will enter Australia as a result of trade in mangosteen fruit from Indonesia and be distributed in a viable state to a susceptible host is: **MODERATE**.

4.1.2 Probability of establishment and spread

As indicated above, the probability of establishment and of spread for *Tetranychus* spp. is assumed to be the same as that assessed for *T. kanzawai* on table grapes from China and Korea (Biosecurity Australia 2011a; Biosecurity Australia 2011b). The ratings from the previous assessments are presented below:

Probability of establishment:	**HIGH**
Probability of spread:	**MODERATE**

4.1.3 Overall probability of entry, establishment and spread

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

The likelihood that *Tetranychus* spp. will enter Australia as a result of trade in mangosteen fruit from Indonesia, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is: **LOW**.

4.1.4 Consequences

The consequences of the establishment of *Tetranychus* spp. in Australia have been estimated previously for table grapes from China and Korea (Biosecurity Australia 2011a; Biosecurity Australia 2011b). This estimate of impact scores is provided below.

Plant life or heath	**E**
Any other aspects of the environment	**B**
Eradication, control, etc.	**D**
Domestic trade	**C**
International trade	**D**
Environment	**B**

Based on the description rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be **MODERATE**.

4.1.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Tetranychus* spp.	
Overall probability of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for *Tetranychus* spp. has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for this pest.

4.2 Weevils [Coleoptera: Curculionidae]

***Curculio* sp.**

Curculio sp. belongs to the weevil family Curculionidae and the subfamily Curculioninae. Weevils of this group are commonly known as 'flower weevils', as the larvae tend to develop within the reproductive plant organs such as flowers, fruit or seeds (Oberprieler *et al.* 2007).

The genus *Curculio* is a large group of weevils distributed across Asia, Europe, Africa and North America. A number of *Curculio* spp. are endemic to the Oriental region (Hughes and Vogler 2004), including Indonesia (Kalshoven 1981; Nasuton 2006).

Most species of *Curculio* breed in the nuts of host plants from the Fagaceae and Betulaceae families. However, *Curculio* sp. is a major pest of mangosteen in Indonesia (Osman and Milan 2006; Nasuton 2006).

In general, *Curculio* weevils are small hard-bodied insects with characteristically long snouts. The snout has small, saw-like teeth at the very end which is used to pierce the nutshell of host plants for oviposition (Kalshoven 1981). Females excavate one or more egg chambers near or in the inner surface of the shell, insert their ovipositors into the hole, and deposit the eggs into each chamber (Gibson 1985; Hughes and Vogler 2004). The eggs usually hatch in 5–14 days and the larvae feed on the nut flesh (Gibson 1985). Depending on the species, larvae development may take two to several weeks (Gibson 1985). When mature, the larvae cut an exit hole in the nutshell. This action may take a few hours to a few days depending on the thickness and hardness of the shell (Gibson 1985). The larvae emerge from the nut and drops to the soil to pupate. Depending on the species, the larvae diapause for 1–2 years before first pupation. The pupal period usually lasts 2–3 weeks (Gibson 1985). On emergence, the adult weevil moves to a nearby tree bearing nuts. Rarely are *Curculio* weevils found on trees without fruit (Gibson 1985).

Although species of the genus *Curculio* are considered 'nut weevils' as they are mainly associated with host plants that bear nuts, they have been found feeding and breeding in mangosteen fruit in Indonesia (Nasuton 2006). *Curculio* sp. can produce up to eight larvae within the mangosteen fruit (Osman and Milan 2006). The larvae complete their development within the mangosteen fruit, feeding on the mesocarp (skin flesh), aril (fleshy seed cover) and seed (Osman and Milan 2006). The larvae will simultaneously become mature as the mangosteen fruit ripens (Nasuton 2006). The mature larvae cut exit holes near the calyx and leave the fruit to pupate in the soil to emerge as an adult (Osman and Milan 2006).

The risk scenario of concern for *Curculio* sp. is the presence of eggs and larvae within imported mangosteen fruit.

4.2.1 Probability of entry

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

Probability of importation

The likelihood that *Curculio* sp. will arrive in Australia with the importation of mangosteen fruit from Indonesia is: **HIGH**.

Supporting information for this assessment is provided below:

- *Curculio* sp. affecting mangosteen occurs in Indonesia (Nasuton 2006).
- Female *Curculio* sp. lay their eggs within the mangosteen fruit. In the genus *Curculio*, the snout is used to drill a hole through the rind of fruit where the eggs are inserted using a long ovipositor that descends from the female's abdomen (Kalshoven 1981; Hughes and Vogler 2004).
- After the eggs hatch, the larvae feed within the mangosteen fruit, consuming the mesocarp, aril and seed (Osman and Milan 2006; Nasuton 2006).
- Infested mangosteen fruit are likely to be harvested as the larvae complete their development within the mangosteen fruit, simultaneously maturing as the mangosteen fruit ripens (Osman and Milan 2006; Nasuton 2006).
- The brushing process is likely to dislodge any adult *Curculio* sp. on the surface of the fruit. However, eggs and larvae develop within the mangosteen fruit (Osman and Milan 2006; Nasuton 2006) and would not be removed by external brushing.
- Immature mangosteen fruit (maturity index 2–3) have a thick pericarp filled with sticky resinous latex that is released when fruit is damaged (Unahawutti and Oonthonglang 2002; Dorly *et al.* 2009). The yellow latex excreted as a result of the entry wounds made by the female for oviposition may be detected during the sorting, grading and packing process and lead to the removal of some infested fruit from the export pathway.

The host status of mangosteen and the development of eggs and larvae within the fruit support a likelihood estimate for importation of 'high'.

Probability of distribution

The likelihood that *Curculio* sp. will be distributed within Australia in a viable state as a result of the processing, sale or disposal of mangosteen fruit from Indonesia and subsequently transfer to a susceptible part of a host is: **LOW**.

Supporting information for this assessment is provided below:

- Mangosteen fruit may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. *Curculio* sp. eggs and larvae are found within the mangosteen fruit and are unlikely to be detected during retail distribution. The pest may enter the environment as larvae discarded with infested mangosteen fruit.
- After arriving in Australia, *Curculio* sp. larvae would need to complete their development within the fruit, exit the fruit, and pupate in a suitable substrate (i.e. soil) to emerge as adults.
- Disposal of infested fruit is likely to be by commercial or domestic rubbish systems or where the fruit is consumed. Some discarded mangosteen fruit may end up close to the soil.
- Infested fruit would need to be discarded near a suitable host so that following pupation the adult will emerge close to a food source. Generally, *Curculio* spp. are host-specific (Anderson 1993), and mangosteens are grown in small areas of far-north Queensland and the Northern Territory. Locating a suitable host would limit the chance of *Curculio* sp. to complete its life cycle.

The evidence that infested fruit may be distributed undetected moderated by the ability of *Curculio* sp. to complete its life cycle near a suitable host and pupation site support a likelihood estimate for distribution of ‘low’.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probabilities of importation and of distribution using the matrix of rules shown in Table 2.2.

The likelihood that *Curculio* sp. will enter Australia as a result of trade in mangosteen fruit from Indonesia and be distributed in a viable state to a susceptible host is: **LOW**.

4.2.2 Probability of establishment

The likelihood that *Curculio* sp. will establish within Australia, based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is: **LOW**.

Supporting information for this assessment is provided below:

- Mangosteens are a host of *Curculio* sp. in Indonesia. Generally, *Curculio* spp. are host specific (Anderson 1993) which limits the ability for *Curculio* sp. to establish in an area deficient of specific host plants.
- *Curculio* sp. is present in the Indonesia where the climate is tropical. Climatic conditions would allow the establishment of *Curculio* sp. in some areas of Australia.
- *Curculio* sp. reproduces sexually. Adults need to emerge from the soil in close proximity to susceptible hosts to ensure adult females can locate a male to mate with and then find a suitable host in which to lay their eggs.
- *Curculio* sp. larvae pupate in the soil. In general, adults emerge from the soil the following year. However, some larvae of the genus may not pupate until as long as five years after entering the soil (Gibson 1985). The long development time required to complete one generation may limit the ability for a population to establish. However, the ability of insect populations to defer pupation for extended periods may increase the chance that a population will persist.
- Natural enemies such as parasitic wasps, entomopathogenic fungi, entomopathogenic nematodes, and some ants (Paparatti and Speranza 2005; Bruck and Walton 2007) affect other *Curculio* spp., and similar organisms may prevent mangosteen –specific *Curculio* sp. from establishing in Australia. Suitable natural enemies may be present in Australia, but their impact is unknown.

The limited host range, the need to find a mate for sexual reproduction and the long generation times support a likelihood estimate for establishment of ‘low’.

4.2.3 Probability of spread

The likelihood that *Curculio* sp. will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest is: **MODERATE**.

Supporting information for this assessment is provided below:

- Generally, *Curculio* spp. are host specific (Anderson 1993). The host range for *Curculio* sp. present in Indonesia is unknown. Mangosteens are grown in small areas of far-north Queensland and Northern Territory and locating a suitable host may limit the chance of *Curculio* spp. completing its life cycle.
- *Curculio* sp. is present in the Indonesia where the climate is tropical. Climatic conditions would allow the spread of *Curculio* sp. in some areas of Australia.
- Dispersal of this pest to previously uninfested areas may occur by transport of fruit infested with *Curculio* sp. eggs and larvae.
- *Curculio* spp. are capable of flight, but it is unknown if they are strong or poor fliers. This may affect their ability to locate a host plant and mate to complete their life cycle.

Climatic suitability in some areas of Australia, moderated by a restricted host range, support a likelihood estimate for spread of ‘moderate’.

4.2.4 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ are shown in Table 2.2.

The likelihood that *Curculio* sp. will enter Australia as a result of trade in mangosteen fruit from Indonesia, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is: **VERY LOW**.

4.2.5 Consequences

The consequences of the establishment of *Curculio* sp. 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 consequences of a pest with respect to one or more criteria are ‘**D**’, the overall consequences are estimated to be **LOW.**

Reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D – Significant at the district level:** • In Indonesia, *Curculio* sp. weevil attack mangosteen fruit (Nasuton 2006). • The main damage caused by *Curculio* sp. includes egg-laying holes in the surface of the fruit and larval feeding within the fruit (Osman and Milan 2006; Nasuton 2006) making the mangosteens unfit for human consumption or unmarketable. • Generally species of *Curculio* are host specific. Therefore it is unlikely that *Curculio* sp. will attack plants other than mangosteens.
Other aspects of the environment	**B – Minor significance at the local level:** • There are no known direct consequences of these pests on other aspects of the environment, but its introduction into a new environment may lead to competition for resources with native species.
Indirect	

Eradication, control etc.	**D – Significant at the district level:** • Additional programs to eradicate *Curculio* sp. on their host plants may be required in infested orchards to reduce fruit damage and yield losses. This may result in a subsequent increase in production costs. • Additionally, costs for crop monitoring and consultant's advice to manage these crops may be incurred by the producer.
Domestic trade	**D – Significant at the local level:** • The presence of these pests in commercial production areas may trigger interstate trade restrictions on mangosteen fruit movement, resulting in additional costs to the producer.
International trade	**D – Significant at the district level:** • The presence of *Curculio* sp. in commercial production areas of Australia is likely to limit access to overseas markets where this pest is absent. • Other countries may impose phytosanitary restrictions or measures to reduce the risk of entry of *Curculio* sp. these restrictions may lead to a loss of international markets.
Environmental and non-commercial	**B – Minor significance at the local level:** • Additional pesticide applications would be required to contain and/or eradicate the pest and control them on susceptible hosts. However, pesticides such as synthetic pyrethroids are already registered for and used in Australian orchards to control other weevil species. Any additional pesticide usage may affect the environment. However, any impact to the environment is likely to be minor at the local level.

4.2.6 Unrestricted risk estimate

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Curculio* sp.	
Overall probability of entry, establishment and spread	Very Low
Consequences	Low
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for *Curculio* sp. has been assessed as 'negligible', which achieves Australia's ALOP. Therefore, no specific risk management measures are required for this pest.

4.3 Fruit flies [Diptera: Tephritidae]

Bactrocera carambolae ^{EP} and *Bactrocera papayae* ^{EP}

Bactrocera carambolae (carambola fruit fly) and *B. papayae* (papaya fruit fly) belong to the fruit fly family Tephritidae that contains some of the most damaging pests of horticultural crops (White and Elson-Harris 1992; Allwood *et al.* 2001). *Bactrocera carambolae* and *B. papayae* are serious pests of a wide range of commercial fruit crops in Southeast Asia (including Indonesia), Oceania, the subcontinent and parts of Africa (White and Elson-Harris 1992; Allwood *et al.* 2001).

The biology and taxonomy of these two species are considered sufficiently similar to justify combining them into a single assessment. In this assessment, the term 'fruit flies' is used to refer to these two species unless otherwise specified.

In Indonesia and Malaysia, *B. papayae* was previously referred to as *B. dorsalis*. The taxon was revised in 1994 and *B. papayae* was described as a distinct species (Drew and Hancock 1994). *Bactrocera papayae* is a polyphagous pest and attacks many species of edible fruits and fleshy vegetables. It has been recorded in Southeast Asia on 193 host plants (Allwood *et al.* 1999). *Bactrocera papayae* was detected in Queensland, Australia in 1995 and was declared eradicated in 1999 (Cantrell *et al.* 2002). In Australia, *B. papayae* bred on 35 host species (Hancock *et al.* 2000).

Bactrocera carambolae originates from Indonesia, Malaysia and southern Thailand (Van Sauers-Muller 2005). This species is less virulent than *B. papayae,* and recorded on 75 host plants (Allwood *et al.* 1999).

Bactrocera species have four life stages: egg, larva, pupa and adult. Adults are predominantly black, or black and yellow. Eggs are laid below the skin of the host fruit (Cantrell *et al.* 2002). Hatched larvae feed within the fruit. Pupation occurs in the soil under the host plant. Fruit flies can produce several generations a year, depending on the temperature (CABI 2011).

Reports of fruit fly infestations in mangosteen are scarce. There is one report of *B. carambolae* and *B. papayae* infesting mangosteen fruit in Southeast Asia (Allwood *et al.* 1999). However, the condition of the infested fruit was not recorded. It is possible that the fruit was damaged.

Extensive research on the host status of mangosteen for both species as well as the related *B. dorsalis* has shown that sound fruit does not support the development of any of these fruit fly species, while infestations of damaged fruit, especially where the aril is accessible, are possible (Leach 1997; Unahawutti and Oonthonglang 2002; Iswari *et al.* 2011).

The risk scenario of concern for *B. carambolae* and *B. papayae* is the presence of eggs and developing larvae within imported mangosteen fruit.

Bactrocera carambolae and *B. papayae* were assessed in the existing import policy for mangosteen fruit from Thailand (DAFF 2004b). The assessment of *B. carambolae* and *B. papayae* presented here builds on this previous assessment.

Differences in the commodity, horticultural practices, climatic conditions and prevalence of fruit flies between previous export areas (Thailand) and Indonesia make it necessary to reassess the likelihood that fruit flies will be imported into and distributed within Australia with mangosteen fruit from Indonesia.

The probability of establishment and spread of *B. carambolae* and *B. papayae* in Australia and the consequences they may cause will be comparable for any commodity from which these species are imported into Australia, as these probabilities 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 risk ratings for establishment, spread and consequences, as set out for *B. carambolae* and *B. papayae* in the mangosteen fruit from Thailand import risk analysis report (DAFF 2004b), will be adopted for this assessment.

4.3.1 Reassessment of probability of entry

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

Reassessment of probability of importation

The likelihood that *B. carambolae* and *B. papayae* will arrive in Australia with the importation of mangosteen fruit from Indonesia is: **EXTREMELY LOW**.

Supporting information for this assessment is provided below:

- *Bactrocera carambolae* and *B. papayae* are present in Indonesia (Van Sauers-Muller 2005).
- *Bactrocera carambolae* and *B. papayae* are polyphagous and are pests of a wide range of commercial fruit including summerfruit, tropical fruit and citrus (Allwood *et al.* 1999).
- In general, female fruit flies deposit eggs beneath the skin of host fruit (CABI 2011). Larvae feed within the fruit for a few days after hatching. Eggs and larvae within the fruit may be difficult to detect.
- *Bactrocera papayae* females have a long ovipositor enabling them to infest hard skinned fruits, including citrus, pawpaw and very young bananas (Pacific Fruit Fly Web 2002).
- Records of fruit flies in mangosteens are rare and often anecdotal. There are no confirmed reports of fruit fly infestations of undamaged mangosteen fruit in the literature. Allwood *et al.* (1999) reported that fruit flies had been reared from mangosteen fruit from Thailand and Malaysia. However, the condition of the fruit (i.e. whether it was sound or damaged, and its maturity level) was not reported. It is possible that the infested fruit was already damaged.
- Mangosteen fruit that are undamaged are considered to be a conditional non-host to fruit flies. *Bactrocera carambolae* and *B. papayae* have been shown to be unable to infest sound mangosteen fruit in laboratory studies in Australia and Indonesia (Leach 1997; Iswari *et al.* 2011).
- In Indonesia, mangosteens are grown in mixed cultivation with other fruit fly host crops such as duku, papaya and banana. Fruit flies favour these crops over mangosteen.

- The flesh of mangosteen fruit is nutritionally supportive for larval growth (Leach 1997; Unahawutti and Oonthonglang 2002; Iswari *et al.* 2011). However, Iswari *et al.* (2011) observed that larvae were still present within the fruit 21 days after fruit fly infestation. The fruit fly larvae were unable to emerge out of the pericarp to complete their life cycle. This may be due to the toxic chemical nature of the mangosteen rind (Leach 1997; Unahawutti and Oonthonglang 2002; Iswari *et al.* 2011).
- Fruit flies will infest mangosteen fruit that is damaged through to the aril. Where fruit flies lay eggs in the pericarp of the mangosteen fruit that is not damaged through to the aril, the larvae cannot penetrate the pericarp to feed on the flesh (Unahawutti and Oonthonglang 2002).
- Indonesia has indicated that undamaged mangosteen fruit at maturity index 2–3 would be exported to Australia. These fruit are considered to be a conditional non-host for fruit flies (Iswari *et al.* 2011). Any fruit that does not meet this criteria (i.e. is visibly damaged or cracked and at maturity index above 3) is easily detected and likely to be removed during the sorting, grading and packing process.
- Mangosteen fruit at maturity index 2–3 have a thick pericarp filled with sticky resinous latex that is released when fruit is damaged (Unahawutti and Oonthonglang 2002; Dorly *et al.* 2009). The secretion of the yellow latex seals off any damage to the mangosteen skin such as feeding punctures, physical cracks or mechanical injuries. The sealing of the mangosteen skin prevents fruit flies from entering the fruit.
- Fruit flies have not been intercepted in Australia on mangosteen fruit imported from Thailand since trade commenced in 2004.

Although fruit flies can infest damaged mangosteen fruit, the conditional non-host status of sound mangosteen fruit, importation of fruit of maturity index 2–3, the inability for larvae to penetrate the fruit skin to complete their life cycle, the fact that damaged and mature fruit which are susceptible to fruit flies are easily detected and the fact that fruit flies have not been detected in imported mangosteen fruit from Thailand support a likelihood estimate for importation of ‘extremely low’.

Reassessment of probability of distribution

The likelihood that *Bactrocera carambolae* and *B. papayae* will be distributed in Australia in a viable state as a result of the processing, sale or disposal of mangosteen fruit from Indonesia and subsequently transfer to a susceptible part of a host is: **HIGH**.

Supporting information for this assessment is provided below:

- Mangosteen fruit may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption.
- Fruit fly eggs and larvae present within the mangosteen fruit and are likely to remain undetected in the fruit during retail distribution. The pest may enter the environment as larvae discarded with infested mangosteen fruit.
- After arriving in Australia, the fruit fly larvae would need to complete their development within the fruit, exit the fruit, pupate in a suitable substrate and emerge as adults.
- Disposal of infested fruit is likely to be by commercial or domestic rubbish systems or where the fruit is consumed. Some infested fruit may be disposed of in the home garden or on the side of the road, where suitable substrates including sand, soil, leaf litter, compost

heaps and grass clippings are available for pupation and in close proximity to possible host plants, so that following pupation the adult will emerge near a suitable food source.

- Fruit fly larvae are unable to emerge from mangosteen fruit to complete their life cycle (Iswari *et al.* 2011) and only mechanical or physical disruption of the mangosteen fruit can assist with the exiting of larvae. However, disruption of the mangosteen fruit by consumers is likely.
- *Bactrocera carambolae* and *B. papayae* are polyphagous and recorded on more than 200 fruit and vegetable crops (Allwood *et al.* 1999). Host plants are widely available in Australia.

The possibility of dispersal near suitable hosts and the wide availability of hosts support a likelihood estimate for distribution of 'high'.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probabilities of importation and of distribution using the matrix of rules shown in Table 2.2.

The likelihood that *B. carambolae* and *B. papayae* will enter Australia as a result of trade in mangosteen fruit from Indonesia and be distributed in a viable state to a susceptible host is: **EXTREMELY LOW**.

4.3.2 Probability of establishment and spread

As indicated above, the probability of establishment and of spread for *B. carambolae* and *B. papayae* would be the same as that assessed for mangosteen fruit from Thailand (DAFF 2004b). The ratings from the previous assessment are presented below:

Probability of establishment:	**HIGH**
Probability of spread:	**HIGH**

4.3.3 Overall probability of entry, establishment and spread

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

The overall likelihood that *B. carambolae* and *B. papayae* will enter Australia as a result of trade in mangosteen fruit from Indonesia, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is: **EXTREMELY LOW**.

4.3.4 Consequences

The consequences of the establishment of *B. carambolae* and *B. papayae* in Australia have been estimated previously for mangosteen fruit from Thailand (DAFF 2004b). This estimate of impact scores is provided below. As the ratings in 2004 were conducted on a scale from A to F, they have been adjusted here to reflect a current rating scale from A to G.

Plant life or heath	**E**
Any other aspects of the environment	**C**
Eradication, control, etc.	**F**
Domestic trade	**E**
International trade	**E**
Environment	**D**

Based on the description rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**F'**, the overall consequences are estimated to be **HIGH**.

4.3.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Bactrocera carambolae* and *Bactrocera papayae*	
Overall probability of entry, establishment and spread	Extremely low
Consequences	High
Unrestricted risk	Very low

As indicated, the unrestricted risk estimate for *B. carambolae* and *B. papayae* has been assessed as 'very low', which achieves Australia's ALOP. Therefore, no specific risk management measures are required for these pests.

4.4 Soft scales [Hemiptera: Coccidae]

Drepanococcus chiton **EP**

Drepanococcus chiton belongs to the family Coccidae or soft scale insects. These are sessile, small and covered with a wax secretion which serves as a protective covering against harsh environmental conditions and predators (Miller and Williams 1997).

The genus *Drepanococcus* contains four species which are restricted to the Afro-tropical, Oriental and Australasian regions of the world (Ben-Dov 2011b). Of the genus, the only species that is recorded present in Indonesia is *D. chiton* (Ben-Dov 2011b).

Drepanococcus chiton is a polyphagous species and has been recorded on hosts from across 15 families. It has been found on a number of subtropical fruit trees and shrubs including papaya, soursop, tea, cocoa, lime and eggplant (Ben-Dov 2011b), and it is considered a pest of carambola in Malaysia (Ibrahim 1994). *Drepanococcus* sp. has been intercepted on mangosteen fruit imported from Thailand into Australia. Given the distribution of the genus, it is almost certain that the intercepted species was *D. chiton*.

Soft scales feed on almost all parts of the host plant. However, most species prefer to feed on the leaves, twigs or trunk (Ben-Dov 2011b). They feed by inserting their piercing and sucking mouthparts into the plant tissue to consume the phloem sap, which is excreted as honeydew (Vranjic 1997). The main economic damage caused by soft scales is from the downgrading of fruit quality caused by sooty mould fungi growing on the honeydew produced by these insects.

The life cycle of the female has an egg stage, three nymphal stages and an adult stage (Ibrahim 1994). Male soft scales have an egg stage, two nymphal stages, a prepupa and pupa stage and an adult stage (Williams 1997). The adult female is similar in appearance to the nymphal stages but is larger in size and covered with a wax secretion (Matile-Ferrero 1997). This contrasts with the adult male, which has a pupal stage, emerging as a winged adult form (Giliomee 1997). The size of mature adult female soft scales varies depending on the species, host plant and feeding site e.g. leaves, stems or twigs (Matile-Ferrero 1997). The adult female of *D. chiton* is approximately 3.5 mm in length, whereas the males are only 2.3 mm in length (Ibrahim 1994).

The adult female mainly reproduces parthenogenetically, that is, without a mate (Ibrahim 1994). However, occasionally males appear in the field, suggesting that females may also reproduce sexually (Ibrahim 1994). *Drepanococcus chiton* can produce around 1000 eggs per female, and the total duration from egg to adult emergence takes approximately 50 days (Ibrahim 1994).

In general, soft scale crawlers hatch and then remain motionless under the scale cover of the adult female for a short period of time. Depending on the environmental conditions this may vary from a few minutes to several days (Marotta 1997). Crawlers are the primary dispersal stage and move to new areas of the plant or are dispersed by wind or animal contact (Greathead 1997a). The dispersal phase may last for several hours to a few days with settling generally occurring within about a metre from the parent female (Marotta 1997). Crawlers that do not settle during the first 24 hours accumulate at the tips of leaves or at the top of host plants to be dispersed by wind currents (Greathead 1997a). Once settled, the crawlers commence feeding and remain sessile throughout the remaining nymphal development stages (Marotta 1997).

The risk scenario of concern for *D. chiton* is the presence of crawlers, immobile juveniles or adult females and their eggs on imported mangosteen fruit.

Drepanococcus chiton (together with other soft scales) were assessed in the existing import policy for longan and lychee fruit from China and Thailand (DAFF 2004a). The assessment of *D. chiton* presented here builds on this previous assessment.

Differences in horticultural practices, climatic conditions and the prevalence of *D. chiton* between previous export areas (China and Thailand) and Indonesia make it necessary to reassess the likelihood that *D. chiton* will be imported into and distributed within Australia with mangosteen fruit from Indonesia.

The probability of establishment and of spread of *D. chiton* in Australia, and the consequences it may cause will be comparable for any commodity from which this species is imported into Australia, as these probabilities 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 risk ratings for establishment, spread and consequences as set out for *D. chiton* in the import risk analysis report for longans and lychees from China and Thailand (DAFF 2004a), will be adopted for this assessment.

4.4.1 Reassessment of probability of entry

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

Reassessment of probability of importation

The likelihood that *D. chiton* will arrive in Australia with the importation of mangosteen fruit from Indonesia is: **HIGH**.

Supporting information for this assessment is provided below:

- *Drepanococcus chiton* occurs throughout Africa and Asia, including Indonesia (Ben-Dov 2011b).
- Soft scales feed on almost all parts of the host plant, which may include the fruit. However, most species prefer the leaves, twigs or trunk (Ben-Dov 1997).
- The life history of soft scales depends on the species and environmental factors. For *D. chiton*, the period from egg to adult emergence is approximately 50 days (Ibrahim 1994). Therefore, *D. chiton* is likely to be present on the fruit when harvested.
- Second instar nymphs produce a waxy cover or ‘test’, which remains intact throughout the subsequent development stages (Miller and Williams 1997). The test protects developing soft scales from harsh environmental conditions, natural enemies and chemical damage (Miller and Williams 1997). Chemical pest control or commercial fruit cleaning may only eliminate first instar nymphs or crawlers and not all of the viable scales present on the fruit surface or under the calyx.
- The small size of nymphs and adult females may make them difficult to detect, especially at low population levels or when they are under the calyx of the fruit. Therefore, the

sorting, grading and packing process may not remove them effectively from the export pathway.

- The brushing process would likely dislodge any crawlers present on the surface of the fruit. However, the sessile stages that are firmly attached to the fruit may remain.
- Soft scales overwinter as second instar nymphs or adult females (Marotta and Tranfaglia 1997). *D. chiton* is likely to survive cold storage and transportation as a species of *Drepanococcus*, most likely *D. chiton*, has been intercepted on mangosteen fruit imported from Thailand into Australia.

The small size, sessile nature of most life stages, cold tolerance and host status all support a likelihood estimate for importation of ‘high’.

Reassessment of probability of distribution

The likelihood that *D. chiton* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of mangosteen fruit from Indonesia and subsequently transfer to a susceptible part of a host is: **LOW**.

Supporting information for this assessment is provided below:

- Mangosteen fruit may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Soft scale eggs, nymphs and adult females may remain on the fruit during retail distribution. The unconsumed parts of the fruit, especially the skin and calyx, are likely to end up in fruit waste, which may further aid distribution of viable scales. Disposal of infested fruit waste is likely to be by commercial or domestic rubbish systems or where the fruit is consumed. Some fruit waste may be disposed of in the home garden which provides an opportunity for *D. chiton* to transfer to susceptible hosts in the vicinity.
- *Drepanococcus chiton* is recorded on a number of host plants including various subtropical fruit trees and shrubs (Campbell 1997; Swirski *et al.* 1997; Greathead 1997b). Host plants are widely available in Australia.
- *Drepanococcus chiton* eggs hatch within 6 days (Ibrahim 1994) and become crawlers. Crawlers are the primary dispersal stage and can also be dispersed by wind or animal contact (Greathead 1997a). The dispersal stage is relatively short, usually lasting from several hours to a few days (Marotta and Tranfaglia 1997), but generally a suitable settling site or feeding site is found within 24 hours (Greathead 1997a). Crawlers do not disperse far on the host plant, generally settling within about a metre from the parent female (Marotta and Tranfaglia 1997).
- The principal natural means of dispersal of crawlers from host plant to host plant is on wind currents (Greathead 1997a).
- Other nymphal stages and adult females are sessile (Ben-Dov 1997). Adult males have wings but only live for a few hours to a few days (Marotta and Tranfaglia 1997), limiting their dispersal ability.
- Mortality is greatest during the crawler stage. Failure to settle is considered to be one of the major mortality factors. Additionally, crawlers lack the waxy protective cover and are susceptible to environmental factors (Marotta and Tranfaglia 1997). *D. chiton* can produce approximately 1000 eggs. However, only 2.5% of the eggs hatched are likely to reach maturity (Ibrahim 1994).

The possibility of dispersal near suitable hosts and the wide availability of hosts, moderated by the short dispersal stage and short travel distance of crawlers and adult males; the sessile status of other life stages; and the high mortality rate of scales reaching maturity support a likelihood estimate for distribution of 'low'.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probabilities of importation and of distribution using the matrix of rules shown in Table 2.2.

The likelihood that *D. chiton* will enter Australia as a result of trade in mangosteen fruit from Indonesia and be distributed in a viable state to a susceptible host is: **LOW**.

4.4.2 Probability of establishment and spread

As indicated above, the probability of establishment and of spread for *D. chiton* is being based on the assessment for longan and lychee fruit from China and Thailand (DAFF 2004a). The ratings from the previous assessment are presented below:

Probability of establishment:	**HIGH**
Probability of spread:	**HIGH**

4.4.3 Overall probability of entry, establishment and spread

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

The likelihood that *D. chiton* will enter Australia as a result of trade in mangosteen fruit from Indonesia, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is: **LOW**.

4.4.4 Consequences

The consequences of the establishment of *D. chiton* in Australia have been estimated previously for longan and lychee fruit from China and Thailand (DAFF 2004a). This estimate of impact scores is provided below. As the ratings in 2004 were conducted on a scale from A to F, they have been adjusted here to reflect a current rating scale from A to G.

Plant life or heath	**D**
Any other aspects of the environment	**B**
Eradication, control, etc.	**C**
Domestic trade	**C**
International trade	**D**
Environment	**B**

Based on the description rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are estimated to be **LOW**.

4.4.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Drepanococcus chiton*	
Overall probability of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very Low

As indicated, the unrestricted risk estimate for *D. chiton* has been assessed as 'very low', which achieves Australia's ALOP. Therefore, no specific risk management measures are required for this pest.

4.5 Armoured scales [Hemiptera: Diaspididae]

Diaspis boisduvalii **^{WA}, *Ischnaspis longirostris*** **$^{EP, WA}$, *Pseudaonidia trilobitiformis*** **$^{EP, WA}$**

Diaspis boisduvalii, *Ischnaspis longirostris* and *Pseudaonidia trilobitiformis* are not present in Western Australia and are pests of regional quarantine concern for that state.

The biology and taxonomy of these three species are considered sufficiently similar to justify combining them into a single assessment. In this assessment, the term ‘armoured scales’ is used to refer to these three species unless otherwise specified.

Diaspis boisduvalii, I. longirostris and *P. trilobitiformis* are members of the family Diaspididae, which produce a hard, fibrous, wax-like covering that attaches the scale to the host plant (Carver *et al.* 1991). Unlike the soft scales, armoured scales do not produce honeydew-like secretions that commonly cause sooty mould to develop (Beardsley and Gonzalez 1975).

The listed armoured scales are near-cosmopolitan and occur throughout the tropics, including Indonesia, and the subtropics of the world. They are also common in greenhouses of the cold to temperate climates of the northern hemisphere (Miller and Davidson 2005a).

Diaspis boisduvalii is a polyphagous species that has been recorded on hosts from 44 genera in 15 families (Miller and Davidson 2005a). It is a pest of economic importance for *Cattleya* orchids in Indonesia (Tjoa 1960). Other hosts include; banana, pineapple, palms, cacti, coffee and coconut (Tenbrink and Hara 1992a; Miller and Davidson 2005a). *Diaspis boisduvalii* is considered a pest of mangosteen plants in Malaysia and is found mainly feeding on the leaves (Yunus and Ho 1980). However, armoured scales feed on all aerial parts of a tree (Kosztarab 1990); therefore *D. boisduvalii* may also be found on mangosteen fruit.

Ischnaspis longirostris is a highly polyphagous species that has been recorded on hosts from 70 genera in 35 families (Miller and Davidson 2005a), including mangosteen (Watson 2005b). It is an economic pest of citrus, coconut, coffee, mango, avocado, banana, palms and greenhouse plants (Miller and Davidson 2005a; CABI 2011).

Pseudaonidia trilobitiformis is also highly polyphagous and has been recorded on hosts from 80 genera in 42 families (Miller and Davidson 2005a). It is an important pest of citrus, cacao, cashew, mango and avocado (Miller and Davidson 2005a), but other horticulture crops and ornamentals are also attacked. *Pseudaonidia trilobitiformis* has been intercepted in the USA on mangosteen fruit from Thailand (USDA-APHIS 2007).

Armoured scales affect their hosts by removing sap, as well as by injecting toxic saliva during feeding (Kosztarab 1990; McClure 1990a). The feeding process results in cell death, deformation of plant parts and the formation of galls and pits, as well as increased susceptibility to other destructive agents such as frosts, disease and other pests (Kosztarab 1990; McClure 1990a). High populations of scales can cause the death of host plants (Beardsley and Gonzalez 1975).

In general, scale nymphs (crawlers) settle and feed on branches, leaves and fruit of the host plant, becoming immobile as they develop into late instar nymphs (Beardsley and Gonzalez 1975; Koteja 1990b). The female life stages includes an adult, egg and nymph, while the male has adult, egg, nymph, pre-pupa and pupa stages (Beardsley and Gonzalez 1975; Koteja

1990b). The female reaches sexual maturity undergoing slight metamorphosis of the internal and external organs (Koteja 1990b). The adult female resembles a slightly larger nymph, remaining legless and immobile on the host plant (Takagi 1990). This contrasts with the male scale, which has a pupal stage, emerging as a winged adult form (Koteja 1990b). The mature adult female is approximately 1.0–1.5 mm in length (Takagi 1990). The mature adult male is seldom seen and is rarely more than 1.0 mm in length (Giliomee 1990).

The adult males of armoured scales only live for 1–3 days (Koteja 1990b). They do not feed and their primary purpose is to locate a female and mate (Koteja 1990b). The adult female can reproduce with or without a male scale (Beardsley and Gonzalez 1975) and will continuously produce offspring for several weeks until death (Koteja 1990a). Female scales will lay 1–10 eggs daily, with some scale species also able to give birth to live young (Beardsley and Gonzalez 1975; Koteja 1990a). The number of offspring produced by a female armoured scale is relatively low, generally around 50–150 (Koteja 1990a). The number of generations per year varies depending on the species and climatic conditions (McClure 1990b) with either eggs, first instar nymphs or adult females overwintering (Beardsley and Gonzalez 1975). The hatched or live-born young remain motionless under the body or scale cover of the adult female for a short period of time before emerging as crawlers. Depending on the environmental conditions this time may vary from half an hour to a couple of days (Beardsley and Gonzalez 1975; Koteja 1990b; Miller and Davidson 2005a). Removal of the mother scale may also trigger the emergence of crawlers (Koteja 1990b).

Crawlers are the primary dispersal stage and move to new areas of the plant or are dispersed by wind or animal contact (Watson 2005c). Although wind is an agent of dispersal, it can also cause mortality because crawlers dislodged by wind may not land on a suitable host plant (Beardsley and Gonzalez 1975; Watson 2005c). The dispersal phase or wandering period lasts for several hours to several days depending on the environmental conditions and availability of feeding sites (Koteja 1990b; Miller and Davidson 2005a). At the end of the wandering period, crawlers secure themselves to the plant host with their mouthparts. Crawlers prefer to settle on the rough or dusty surfaces of the plant (Koteja 1990b). Once settled, the crawlers draw their legs beneath the body and flatten themselves against the host to commence feeding and develop a protective covering (Beardsley and Gonzalez 1975; Koteja 1990b). They feed by inserting their piercing and sucking mouthparts into the plant tissue to consume the plant juices (Koteja 1990b). Dispersal of sessile adults and eggs occurs through human transport of infested plant material (Watson 2005c).

The risk scenario of concern for *D. boisduvalii, I. longirostris* and *P. trilobitiformis* is the presence of crawlers, immobile juveniles or adult scales under the calyx of imported mangosteen fruit.

Pseudaonidia trilobitiformis was assessed in the existing import policy for Tahitian limes from New Caledonia (Biosecurity Australia 2006a). *Ischnaspis longirostris* was assessed in the existing import policy for unshu mandarin from Shizuoka Prefecture in Japan (Biosecurity Australia 2009). The assessment of *D. boisduvalii*, *I. longirostris* and *P. trilobitiformis* presented here builds on these previous assessments.

Differences in horticultural practices, climatic conditions and the prevalence of *I. longirostris* and *P. trilobitiformis* between previous export areas (Japan and New Caledonia) and Indonesia make it necessary to reassess the likelihood that *D. boisduvalii*, *I. longirostris* and *P. trilobitiformis* will be imported into and distributed within Western Australia with mangosteen fruit from Indonesia.

The probability of establishment and of spread of *D. boisduvalii*, *I. longirostris* and *P. trilobitiformis* in Western Australia and the consequences they may cause will be comparable for any commodity from which this species is imported into Western Australia, as these probabilities relate specifically to events that occur in Western Australia and are largely independent of the importation pathway. Accordingly, there is no need to reassess these components, and the estimates of the risk ratings for establishment, spread and consequences as set out for *I. longirostris* in the unshu mandarin from Japan import risk analysis report (Biosecurity Australia 2009) and for *P. trilobitiformis* in the Tahitian limes from New Caledonia import risk analysis report (Biosecurity Australia 2006a), will be adopted for this assessment.

4.5.1 Reassessment of probability of entry

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

Reassessment of probability of importation

The likelihood that *D. boisduvalii, I. longirostris* and *P. trilobitiformis* will arrive in Western Australia with the importation of mangosteen fruit from Indonesia is: **HIGH**.

Supporting information for this assessment is provided below:

- *Diaspis boisduvalii, I. longirostris* and *P. trilobitiformis* are widely distributed throughout the tropical and subtropical areas of the world (Miller and Davidson 2005a). All three species are present in Indonesia (Tjoa 1960; Miller *et al.* 2011; Ben-Dov 2011c).
- Most armoured scales are eurymerous, that is, they feed on various parts of the host plant (Beardsley and Gonzalez 1975). Armoured scales usually settle, feed and reproduce on the aerial parts of the tree, particularly plant organs with a thick epidermal layer such as leaves, fruit and branches (Beardsley and Gonzalez 1975; Kosztarab 1990).
- Mangosteen is a known host for *D. boisduvalii* and *I. longirostris* (Yunus and Ho 1980; Watson 2005b). *Diaspis boisduvalii* is considered an economic pest of mangosteen in Malaysia (Yunus and Ho 1980).
- *P. trilobitiformis* has been intercepted in USA on mangosteen fruit from Thailand (USDA-APHIS 2007).
- First instar nymphs or crawlers are capable of moving onto the fruit where they permanently attach and commence feeding (Beardsley and Gonzalez 1975). Subsequent nymphs and adults inside the scale covers are sessile and remain attached to the host plant.
- The life history of armoured scales depends on the species and environmental factors. For *D. boisduvalii*, the period from egg to egg laying females requires about 50 days and development from egg to adult stage for males averages around 33 days (Miller and Davidson 2005a). Therefore, armoured scales are likely to be present on the fruit when harvested.
- Armoured scales have a relatively hard, impermeable external covering or ‘scale’ (Foldi 1990) that can protect them from physical and chemical damage. Chemical pest control or commercial fruit cleaning may not eliminate all viable scales present on the fruit surface or under the calyx.

- Adult females are small, approximately 1.0–1.5 mm in length (Takagi 1990). The male is even smaller, seldom exceeding over 1.0 mm in length (Giliomee 1990). The small size of the adults, nymphs and eggs, may make them difficult to detect, especially at low populations. Therefore, armoured scales may not be easily removed during sorting, grading and packing processes, especially when they are under the calyx of the fruit.
- The brushing process would likely dislodge a number of scales on the surface of the fruit. Any crawlers present would be easily dislodged. However, sessile stages that are firmly attached to the fruit may remain.
- Armoured scales overwinter as eggs, first instar nymphs or adult females (Beardsley and Gonzalez 1975). *Pseudaonidia trilobitiformis* is likely to survive cold storage and transportation as they have been intercepted on mangosteen fruit imported from Thailand into the USA (USDA-APHIS 2007).

The small size, sessile nature of most life stages, cold tolerance and host status all support a likelihood estimate for importation of ‘high’.

Reassessment of probability of distribution

The likelihood that *D. boisduvalii, I. longirostris* and *P. trilobitiformis* will be distributed within Western Australia in a viable state as a result of the processing, sale or disposal of mangosteen fruit from Indonesia and subsequently transfer to a susceptible part of a host is: **LOW**.

Supporting information for this assessment is provided below:

- Mangosteen fruit may be distributed throughout Western Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- *Diaspis boisduvalii, I. longirostris* and *P. trilobitiformis* eggs, nymphs and adults may remain on the fruit during retail distribution. The unconsumed parts of the fruit, especially the skin and calyx of infested fruit, are likely to end up in fruit waste, which may further aid distribution of viable scales. Disposal of infested fruit waste is likely to be by commercial or domestic rubbish systems or where the fruit is consumed. Some fruit waste may be disposed of in the home garden which provides an opportunity for *D. boisduvalii, I. longirostris* and *P. trilobitiformis* to transfer to susceptible hosts in the vicinity.
- *D. boisduvalii, I. longirostris* and *P. trilobitiformis* are polyphagous and attack a number of host plants including fruit and nut trees, ornamental shade trees, flowering plants, palms, cacti, ground covers and forest trees (Kosztarab 1990; Miller and Davidson 2005a). Host plants are widely available in Western Australia.
- Eggs hatch within 5–7 days and become crawlers (Miller and Davidson 2005a). Crawlers are the mobile stage of the species and can also be dispersed by wind (Watson 2005c). The crawler stage of scales is rather short, lasting about 9 days (Miller and Davidson 2005a).
- Other nymphal stages and adult females are sessile and not mobile (Beardsley and Gonzalez 1975). Adult males have wings and are able to fly short distances but only live for a few days (Giliomee 1990; Koteja 1990b), limiting their dispersal ability.

The possibility of dispersal near suitable hosts and the wide availability of hosts, moderated by the short dispersal stage of crawlers on infested mangosteen fruit, and by the sessile status of other life stages, support a likelihood estimate for distribution of ‘low’.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probabilities of importation and of distribution using the matrix of rules shown in Table 2.2.

The likelihood that *D. boisduvalii, I. longirostris* and *P. trilobitiformis* will enter Western Australia as a result of trade in mangosteen fruit from Indonesia and be distributed in a viable state to a susceptible host is: **LOW**.

4.5.2 Probability of establishment and spread

As indicated above, the probability of establishment and of spread for these armoured scales is being based on the assessment for unshu mandarin from Japan (Biosecurity Australia 2009) and Tahitian limes from New Caledonia (Biosecurity Australia 2006a). The ratings from the previous assessments are presented below:

Probability of establishment:	**HIGH**
Probability of spread:	**MODERATE**

4.5.3 Overall probability of entry, establishment and spread

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

The likelihood that *D. boisduvalii, I. longirostris* and *P. trilobitiformis* will enter Western Australia as a result of trade in mangosteen fruit from Indonesia, be distributed in a viable state to a susceptible host, establish in Western Australia and subsequently spread within Western Australia is: **LOW**.

4.5.4 Consequences

The consequences of the establishment of *I. longirostris* and *P. trilobitiformis* in Western Australia have been estimated previously for unshu mandarin from Japan (Biosecurity Australia 2009) and Tahitian limes from New Caledonia (Biosecurity Australia 2006a) respectively. This estimate of impact scores is provided below. As the ratings in 2006 were conducted on a scale from A to F, they have been adjusted here to reflect a current rating scale from A to G.

Plant life or heath	**D**
Any other aspects of the environment	**B**
Eradication, control, etc.	**D**
Domestic trade	**C**
International trade	**C**
Environment	**B**

Based on the description rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are estimated to be **LOW**.

4.5.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Diaspis boisduvalii, Ischnaspis longirostris,* and *Pseudaonidia trilobitiformis*	
Overall probability of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very Low

As indicated, the unrestricted risk estimate for *D. boisduvalii*, *I. longirostris* and *P. trilobitiformis* has been assessed as ‘very low’, which achieves Australia’s ALOP. Therefore, no specific risk management measures are required for these pests.

4.6 Mealybugs [Hemiptera: Pseudococcidae]

Dysmicoccus lepelleyi, Exallomochlus hispidus, Hordeolicoccus heterotrichus, Paracoccus interceptus, Paraputo odontomachi, Planococcus lilacinus ^{EP}***, Planococcus minor*** $^{EP, WA}$***, Pseudococcus aurantiacus, Pseudococcus baliteus, Pseudococcus cryptus*** ^{EP}***, Rastrococcus spinosus*** ^{EP}

Planococcus minor is not present in Western Australia and is a pest of regional quarantine concern for that state.

The biology and taxonomy of these eleven mealybug species are considered sufficiently similar to justify combining them into a single assessment. In this assessment, the term ‘mealybugs’ is used to refer to these eleven species unless otherwise specified.

Dysmicoccus lepelleyi (annona mealybug)*, E. hispidus* (cocoa mealybug)*, H. heterotrichus* (citrus mealybug), *P. interceptus* (intercepted mealybug), *P. odontomachi*, *P. lilacinus* (coffee mealybug), *P. minor* (pacific mealybug), *P. aurantiacus* (orange-coloured mealybug), *P. baliteus* (aerial root mealybug)*, P. cryptus* (cryptic mealybug) and *R. spinosus* (Philippine mango mealybug) belong to the Pseudococcidae or mealybug family.

Mealybugs are highly polyphagous and have been recorded on a wide range of host plants including mangosteens. The listed mealybug species are found throughout the Oriental region of the world, including Indonesia. However, *P. lilacinus* and *P. cryptus* are more widespread with *P. lilacinus* distributed throughout the Palaearctic, Malaysian, Australasian and Neotropical regions of the world and *P. cryptus* throughout tropical Africa, the mid-eastern Mediterranean, South America, Oceania and Korea (Ben-Dov 2011d).

Mealybugs are small, oval, soft-bodied insects that are covered with a white, cottony or mealy wax secretion that is moisture repellent and protects them against desiccation (Cox 1987; Furness and Charles 1994). These pests are sucking insects that injure plants by extracting large quantities of sap. This weakens and stunts plants, causing leaf distortion, premature leaf drop, dieback and even plant death (Osborne *et al.* 2005). They may also cause indirect damage by injecting toxins or plant pathogens into host plants. For example, *P. lilacinus* transmits Ceylon cocoa virus in Sri Lanka (Williams 2004). Mealybugs deposit a waste product, ‘honeydew’, on the leaves and fruit as they feed, which serves as a food source for ants or a substrate for the development of sooty mould (Spangler and Agnello 1991). Sooty mould prevents photosynthesis in addition to making the plant, including the fruit, unsightly.

Mealybugs develop through a number of nymphal (immature instar) stages before undergoing a final moult into the adult form. Female mealybugs have four instar stages (Williams 2004), with the adult female being similar in appearance to the nymphal stage and approximately 4 mm in length. This contrasts with male mealybugs, which have five instar stages (Williams 2004), with the adult male emerging from a cocoon as a tiny winged form. The adult males do not feed, having no mouthparts, and their sole purpose is to locate a female and mate. Mealybugs reproduce sexually or parthenogenically, that is, without a mate, and there may be multiple generations per year. Females can produce up to 800 eggs (Ooi *et al.* 2002) in compact waxy sacs attached to the stems, leaves or fruit of host plants. The females die shortly after the eggs are laid. The eggs hatch around 1–2 weeks later (Ooi *et al.* 2002) into tiny yellowish crawlers (first instar nymphs).

Generally, mealybugs prefer warm, humid, sheltered sites away from adverse climatic conditions and natural enemies. Mealybug eggs, nymphs and adult females are very small and even though they usually infest the leaves and stems of host plants, they may be found in crevices and protected spaces, such as under the calyx of mangosteen fruit. This makes them difficult to detect and potentially a serious problem in mangosteen production areas. Additionally, many mealybug species pose serious problems to agriculture when introduced into new areas of the world where natural enemies are not present (Miller and Miller 2002).

The risk scenario of concern for the listed mealybug species is the presence of eggs, nymphs or adult females in crevices or protected areas, such as under the calyx, of imported mangosteen fruit.

Planococcus cryptus was assessed in the existing import policy for mangosteens from Thailand (DAFF 2004b); *P. lilacinus*, *R. spinosus* and *P. cryptus* in the existing import policy for fresh mangoes from Taiwan (Biosecurity Australia 2006b) and *P. minor* in the existing import policy for bananas from the Philippines (Biosecurity Australia 2008). The assessment of the mealybug species listed here builds on these previous assessments.

Differences in commodity, horticultural practices, climatic conditions and the prevalence of the listed mealybugs between previous export areas (Thailand, Taiwan and the Philippines) and Indonesia make it necessary to reassess the likelihood that the listed mealybugs will be imported into and distributed within Australia with mangosteen fruit from Indonesia.

The probability of establishment and of spread of the listed mealybugs in Australia and the consequences they may cause will be comparable for any commodity from which this species is imported into Australia, as these probabilities 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 estimates of the risk ratings for establishment, spread and consequences as set out for *P. cryptus* in the mangosteen fruit from Thailand import risk analysis report (DAFF 2004b), for *P. lilacinus*, *R. spinosus* and *P. cryptus* in the mangoes from Taiwan import risk analysis report (Biosecurity Australia 2006b) and for *P. minor* in the bananas from the Philippines import risk analysis report (Biosecurity Australia 2008), will be adopted for this assessment.

4.6.1 Reassessment of probability of entry

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

Reassessment of probability of importation

The likelihood that *D. lepelleyi*, *E. hispidus*, *H. heterotrichus*, *P. interceptus*, *P. odontomachi*, *P. lilacinus*, *P. aurantiacus*, *P. baliteus*, *P. cryptus*, *R. spinosus* will arrive in Australia or that *P. minor* will arrive in Western Australia with the importation of mangosteen fruit from Indonesia is: **HIGH.**

Supporting information for this assessment is provided below:

- Mealybugs are distributed worldwide and are present in Indonesia (Ben-Dov 2011d). They are considered a pest of mangosteens in Indonesia, attacking the leaves and fruits (IAQA 2008).

- Once mealybugs find a suitable feeding site, they insert their stylets (mouthparts) and suck sap from the host plant. This procedure anchors the mealybugs to the plant where they generally remain (Williams 2004). Once feeding begins, they secrete a waxy mealy coating that helps protect their bodies.
- Adult female mealybugs and nymphs (that is, immature male and female mealybugs) are small (1–4 mm), oval shaped, often inconspicuous, lack wings and have limited mobility (Spangler and Agnello 1991). The wingless adult females usually live in sheltered positions (Cox 1987), such as under the calyx of mangosteen fruit.
- Mangosteens packed for export typically consist of the fruit with a short pedicel and the calyx consisting of four sepals. Mealybugs can hide under the calyx and may not be detected during routine visual inspection procedures within the packing house. Inspection procedures focus primarily on quality standards of the fruit with regards to blemishes, premature ripening, bruising or damage to the skin and calyces. The procedures are not particularly directed at the detection of small arthropod pests which may be present under the calyx.
- The brushing process would likely dislodge some mealybug species present on the surface of the fruit. However, mealybugs have a tendency to feed and deposit their eggs in secluded places and the brushing process may not remove mealybugs and/or eggs located under the calyx of the mangosteen fruit.
- Mealybugs are likely to survive storage and transportation. There is no data for the listed mealybugs regarding their tolerance to prolonged periods of cold temperatures. However, the mealybug *Pseudococcus affinis* can survive for up to 42 days at 0˚C (Hoy and Whiting 1997).
- There is strong potential for mealybugs to be associated with mangosteen fruit after storage and transportation, as live mealybugs have been intercepted on Thai mangosteens imported into the USA (USDA-APHIS 2007) and Australia.

The association of mealybugs with the fruit, the small size, sessile and cryptic nature of most life stages plus their previous interception on arrival, all support a likelihood estimate for importation of ‘high’.

Reassessment of probability of distribution

The likelihood that *D. lepelleyi*, *E. hispidus, H. heterotrichus, P. interceptus, P. odontomachi, P. lilacinus, P. aurantiacus, P. baliteus, P. cryptus,* and *R. spinosus* will be distributed within Australia or that *P. minor* will be distributed within Western Australia in a viable state as a result of the processing, sale or disposal of mangosteen fruit from Indonesia and subsequently transfer to a susceptible part of a host is: **MODERATE**.

Supporting information for this assessment is provided below:

- Mangosteen fruit may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. Waste material may be generated.
- Mealybug eggs, nymphs and adult females may remain on the fruit during retail distribution. The unconsumed parts of the fruit, especially the skin and calyx of infested fruit, are likely to end up in fruit waste, which may further aid distribution of viable mealybugs. Disposal of infested fruit is likely to be by commercial or domestic rubbish systems or where the fruit is consumed. Some fruit waste may be disposed of in the home

garden which provides an opportunity for mealybugs to transfer to susceptible hosts in the vicinity.

- Mealybugs have a high fecundity, and can produce up to 800 eggs (e.g. *P. minor* and *P. lilacinus*, Ooi *et al*. 2002).
- Crawlers (first instar nymphs) are the primary dispersal phase and are capable of active dispersal by crawling and passive dispersal by wind currents (Hely *et al.* 1982; Rohrbach *et al.* 1988). However, mealybugs can survive for only a short time (approximately one day) without feeding (Osborne *et al.* 2005).
- Adult females can only crawl a few metres, restricting their ability to move from discarded fruit waste to a suitable host (CABI 2011).
- Once mealybugs find a suitable feeding site they become sessile. They insert their stylets into the plant host and remain permanently attached.
- Mealybugs are polyphagous. A range of plants which are widely distributed in Australia can act as host for these pests (see Appendix B). However, lack of active long-distance dispersal mechanisms may moderate the rate of incursion of these pest species.

The possibility of dispersal near suitable hosts, the wide availability of hosts and the high fecundity of mealybugs, moderated by the lack of long distance dispersal mechanisms support a likelihood estimate for distribution of ‘moderate’.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probabilities of importation and of distribution using the matrix of rules shown in Table 2.2.

The likelihood that *D. lepelleyi*, *E. hispidus*, *H. heterotrichus*, *P. interceptus*, *P. odontomachi*, *P. lilacinus, P. aurantiacus*, *P. baliteus*, *P. cryptus*, and *R. spinosus* will enter Australia or that *P. minor* will enter Western Australia as a result of trade in mangosteen fruit from Indonesia and be distributed in a viable state to a susceptible host is: **MODERATE**.

4.6.2 Probability of establishment and spread

As indicated above, the probability of establishment and of spread for the listed mealybug species is being based on the assessment for *P. cryptus* on mangosteens from Thailand (DAFF 2004b); for *P. lilacinus*, *R. spinosus* and *P. cryptus* on mangoes from Taiwan (Biosecurity Australia 2006b) and for *P. minor* on bananas from the Philippines (Biosecurity Australia 2008). The ratings from the previous assessments are presented below:

Probability of establishment:	**HIGH**
Probability of spread:	**HIGH**

4.6.3 Overall probability of entry, establishment and spread

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

The likelihood that *D. lepelleyi*, *E. hispidus*, *H. heterotrichus*, *P. interceptus*, *P. odontomachi*, *P. lilacinus*, *P. aurantiacus*, *P. baliteus*, *P. cryptus*, and *R. spinosus* will enter Australia or that

P. minor will enter Western Australia as a result of trade in mangosteen fruit from Indonesia, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is: **MODERATE.**

4.6.4 Consequences

The consequences of the establishment of *P. lilacinus, P. cryptus, P. minor* and *R. spinosus* in Australia have been estimated previously for mangosteens from Thailand (DAFF 2004b), mangoes from Taiwan (Biosecurity Australia 2006b), and bananas from the Philippines (Biosecurity Australia 2008). This estimate of impact scores is provided below. As the ratings in 2004 were conducted on a scale from A to F, they have been adjusted here to reflect a current rating scale from A to G.

Plant life or health	**D**
Any other aspects of the environment	**B**
Eradication, control etc.	**D**
Domestic trade	**C**
International trade	**D**
Environment	**B**

Based on the description rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are ‘D’, the overall consequences are estimated to be **LOW**.

4.6.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Dysmicoccus lepelleyi, Exallomochlus hispidus, Hordeolicoccus heterotrichus, Paracoccus interceptus, Paraputo odontomachi, Planococcus lilacinus, Planococcus minor, Pseudococcus aurantiacus, Pseudococcus baliteus, Pseudococcus cryptus* and *Rastrococcus spinosus*	
Overall probability of entry, establishment and spread	Moderate
Consequences	Low
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for *D. lepelleyi, E. hispidus, H. heterotrichus, P. interceptus, P. odontomachi, P. lilacinus, P. minor, P. aurantiacus, P. baliteus, P. cryptus*, and *R. spinosus* has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for these pests.

4.7 Ants [Hymenoptera: Formicidae]

Camponotus **sp.,** ***Cardiocondyla*** **sp.,** ***Crematogaster*** **sp.,** ***Dolichoderus sp.*** **EP,** ***Iridomyrmex*** **sp.,** ***Monomorium*** **sp.,** ***Paratrechina*** **sp.,** ***Pheidole*** **sp.,** ***Plagiolepis*** **sp.,** ***Polyrhachis*** **sp.,** ***Tapinoma*** **sp.,** ***Technomyrmex*** **sp. EP,** ***Tetramorium*** **sp. and** ***Wasmannia auropunctata*** **EP**

The role of ants is very important in the ecology of many insect pests in the tropics. In Indonesian agriculture, ants cause only limited direct damage as little living plant material other than seeds is taken as food (Kalshoven 1981). However, the indirect influence of ants is considerable. Ants are attracted to the honeydew excreted by sap-sucking hemipterans, and in exchange, ants protect the bugs from their natural enemies and the growth of sooty mould (Lach and Thomas 2008). Invasive ants may be especially adept at tending hemipterans because of their liking for carbohydrate resources, their aggression and abundance (Helms and Vinson 2002; Holway *et al.* 2002). Ants also harvest seeds, feed on nursery seedlings, and are a nuisance to farmers and agricultural workers due to their stings and bites as well as assist in the distribution of weed seeds (Kalshoven 1981).

The biology of the ant species in these 14 genera is considered sufficiently similar to justify combining them into a single assessment. In this assessment, the term 'ants' is used to refer to these genera unless otherwise specified.

Crematogaster include many species of tree-dwelling ants which form colonies in enlarged bark crevices of trunks or branches. They feed on the sugary substances produced by sucking insects, on animal refuse and are occasionally carnivorous. They frequently construct protected covers over aphid and mealybug colonies which leads to the enhanced development of these sucking insects (Kalshoven 1981).

Dolichoderus is an important genus of ants that feed mainly on the honeydew produced by sucking insects, which creates a close symbiosis. They nest in shaded sites in trees, seldom on the ground (Kalshoven 1981). For example, *Dolichoderus bituberculatus* is a very common tree-dwelling species that occurs in shaded places in cultivated areas in all parts of Java below 1300 m. The ants feed on honeydew, as well as nectar from flowers, resinous secretions (bamboo), pollen and fruiting fungal structures. These ants regularly tend the long tailed mealybug (*Planococcus lilacinus*), green scale (*Coccus viridis*), white flies (Aleyrodidae), small tree hoppers (Membracidae) and Psyllidae (Kalshoven 1981). It is known that the presence of the ants favours the development of the green scale as well as the white cacao mealybug. The mealybugs are protected by the ants which cover the colonies with papery material (Kalshoven 1981). The survival of the mealybug may depend on the presence of these ants (Kalshoven 1981).

Iridomyrmex species are both ground and tree-dwelling and may assist in the distribution of noxious epiphytic plants on crops in Indonesia (Kalshoven 1981).

Monomorium species live mostly above ground in narrow spaces and crevices. For example, *Monomorium floricola* is common in the field in Indonesia, tending aphids in shrubs and trees (Kalshoven 1981).

Plagiolepis and *Anoplolepis* species nest on the surface of the ground in leaf litter or decaying stems. One species, *A. gracilipes* is a very common ant found in Java up to 1200 m (Kalshoven 1981) and has been spread throughout the tropics by human activity (CSIRO

2011). It plays an important role in tending pests such as mealybugs, scales and cicadellid leafhoppers for their honeydew and therefore is considered a pest of several crops (Kalshoven 1981; GISD 2009). The ants feed on the honeydew from coccids and cicadellid leafhoppers, in coffee on *Coccus viridis* and *Planococcus citri*, in cacao on *P. lilacinus*, on mango on the cicadellid leafhopper, *Idiocerus* (Kalshoven 1981). The ants tend the green coccid, enhancing the survival rate of this pest; parasitism of the coccids decreases, which can lead to a 20-fold increase in the number of progeny produced. A similar situation exists on coffee in east Java, where the mealybug *Planococcus citri* is tended during the rainy season (Kalshoven 1981).

An invasive species of *Technomyrmex*, the white-footed ant (*Technomyrmex albipes*) is widespread throughout the Indo-Australian region and is known to feed on honeydew secreted by mealybugs, aphids, soft scales and whiteflies. *Technomyrmex albipes* farms these sap-sucking Hemiptera, protecting them from parasites and predators and in areas where this ant is present parasitisation of mealybugs is lower and predation by other arthropods is lower (Nechols and Seibert 1985; Tenbrink and Hara 1992b).

The little fire ant, *Wasmannia auropunctata*, nests in twigs and leaf litter as well as inside houses (Smith 1965; Armbrecht and Ulloa-Chacón 2003; Brooks and Nickerson 2011). As an invasive ant it readily invades disturbed habitats, such as forest edges or agricultural fields (Ness and Bronstein 2004) and is able to exploit resources including nectar and honeydew residues of hemipteran insects such as coccids, leafhoppers, mealybugs, scales, psyllids and white flies (Fernald 1947; Armbrecht and Ulloa-Chacón 2003; IPPC 2012). *Wasmannia auropunctata* is easily transported on fruits and vegetables, and growing trade between countries has facilitated its colonisation in many parts of the world (Causton *et al.* 2005). Since its discovery in Queensland in 2006, *W. auropunctata* has been listed as a declared species under the Plant Protection Act 1989, and is under official control (DEEDI 2011).

Several of the listed ant genera contain species that are known to be invasive, including *Anoplolepis* (originally a subgenus of *Plagiolepis*), *Cardiocondyla, Monomorium, Paratrechina, Pheidole, Tapinoma, Technomyrmex* and *Wasmannia* (Lowe *et al.* 2000; GISD 2009), and as such these ants have attributes that make them successful invaders. These attributes include adaptability to a wide range of habitats, high interspecific aggression and lack of intraspecific aggression which leads to unicoloniality (Ulloa-Chacon and Cherix 1990; Le Breton *et al.* 2004). Colonies containing numerous reproducing females (queens) (Holldobler and Wilson 1977) increase the likelihood that small numbers of ants that are split off from a colony with a queen, and are transported by humans in commerce are able to found new colonies.

Although ants are not plant pests injurious to plants or plant products as such, it is expected that due to their habit of protecting honeydew-excreting Hemiptera from predators and parasites and feeding on the honeydew (Fernald 1947; Kalshoven 1981; Nechols and Seibert 1985; Tenbrink and Hara 1992b; Causton 2001; Causton *et al.* 2005), they will be present on the pathway for mangosteens from Indonesia. As a number of ant genera identified in the pest categorisation stage are known to protect and feed on the honeydew excreted by several Hemiptera, including Coccoidea, and since the risk scenario of concern for the mealybugs and scales is their presence under the calyx of imported mangosteen fruit, it is expected that ants may also be present as evidenced by the interception of several species of ants on mangosteens from Thailand.

The risk scenario of concern for the ants listed is the presence of ants under the calyx of imported mangosteen fruit.

Wasmannia auropunctata was assessed in the existing policy for Tahitian limes from New Caledonia (Biosecurity Australia 2006a). *Technomyrmex butteli* and an unidentified *Dolichoderus* species were assessed in the existing policy for mangosteens from Thailand (DAFF 2004b). The assessment of the unidentified ant species presented here builds on these previous assessments.

Differences in commodity, horticultural practices, climatic conditions and the prevalence of the listed ants between previous export areas (Thailand and New Caledonia) and Indonesia make it necessary to reassess the likelihood that the listed ants will be imported into and distributed within Australia with mangosteen fruit from Indonesia.

The probability of establishment and spread of the listed ants in Australia, and the consequences they may cause will be comparable for any commodity in which the ants are imported into Australia, as these probabilities 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 estimates of the risk ratings for establishment, spread and consequences as set out for the little fire ant (*Wasmannia auropunctata*) in the Tahitian limes from New Caledonia import risk analysis report (Biosecurity Australia 2006a), will be adopted for this assessment.

4.7.1 Reassessment of probability of entry

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

Reassessment of probability of importation

The likelihood that *Camponotus* sp., *Cardiocondyla* sp., *Crematogaster* sp., *Dolichoderus* sp., *Iridomyrmex* sp., *Monomorium* sp., *Paratrechina* sp., *Pheidole* sp., *Plagiolepis* sp., *Polyrhachis* sp., *Tapinoma* sp., *Technomyrmex* sp., *Tetramorium* sp., and *Wasmannia auropunctata* will arrive in Australia with the importation of mangosteen fruit from Indonesia is: **HIGH**.

Supporting information for this assessment is provided below:

- Mangosteens packed for export typically consist of the fruit with a short pedicel and the calyx consisting of four sepals. Ants can hide under the calyx and may not be detected during routine visual inspection procedures within the packing house. Inspection procedures focus primarily on quality standards of the fruit with regards to blemishes, premature ripening, bruising or damage to the skin and calyces. The procedures are not particularly directed at the detection of small arthropod pests which may be present under the calyx.
- Many species of the above listed genera are small in size, ranging from 1.5–2.4 mm for species of *Monomorium*, *Tapinoma* and *Wasmannia* to as long as 3–4.5 mm for species of *Dolichoderus*, *Technomyrmex, Tetramorium, Paratrechina* and *Pheidole* (Chin 2008; CSIRO 2011).
- Many species in the above listed genera of ants are attracted to honeydew secreted by mealybugs and scales (Fernald 1947; Kalshoven 1981; Nechols and Seibert 1985; Causton 2001; Causton *et al.* 2005) and would be found attending these hemipterans on mangosteens.

- Species of *Technomyrmex* and *Dolichoderus* have been observed hiding under the calyces of mangosteen fruit in Thailand (Biosecurity Australia 2003).
- Ants have been observed constructing nests under the calyces of mangosteen fruit in Thailand (Biosecurity Australia 2003).
- Cleaning may remove some ant species on the fruit but effective removal of all ants may be difficult.
- This is evidenced by the interception of unidentified ant species of 14 genera on mangosteens imported into Australia from Thailand.
- Queens and workers of *Wasmannia auropunctata* have been intercepted on arrival in Australia on produce imported from Bolivia, New Caledonia, Singapore, Solomon Islands, USA, Vanuatu and Vietnam.
- *Wasmannia auropunctata* is a common invasive "tramp" ant species that has spread widely throughout the warmer regions of the world, due to its ability to hitch-hike in commodities (Brooks and Nickerson 2011).
- *Wasmannia auropunctata* has been accidentally introduced to New Caledonia and is spreading (Fabres and Brown 1978) and has been detected in north Queensland and is subject to an eradication program (DEEDI 2011; IPPC 2012).
- The interception of unidentified ant species on commodities on arrival in Australia suggests that: postharvest procedures will not remove all ants; quality control inspectors within the packing house are likely to miss some infested fruit; and ants will survive storage and transportation.

The presence of unidentified ant species on mangosteen trees in Indonesia, the interception of ants on mangosteens from Thailand, the association of ants with fruit and the presence of mealybugs and scales under the sepals, the mutualistic relationship between ants and honeydew secreting hemipterans, their small size, sessile and cryptic nature of most life stages all support a likelihood estimate for importation of 'high'.

Reassessment of probability of distribution

The likelihood that *Camponotus* sp., *Cardiocondyla* sp., *Crematogaster* sp., *Dolichoderus* sp., *Iridomyrmex* sp., *Monomorium* sp., *Paratrechina* sp., *Pheidole* sp., *Plagiolepis* sp., *Polyrhachis* sp., *Tapinoma* sp., *Technomyrmex* sp., *Tetramorium* sp., and *Wasmannia auropunctata* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of mangosteen fruit from Indonesia and subsequently transfer to a susceptible part of a host is: **HIGH**.

Supporting information for this assessment is provided below:

- Mangosteen fruit may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. Waste material may be generated.
- Ants may remain on the fruit during retail distribution. The unconsumed parts of the fruit, especially the skin and calyx of infested fruit, are likely to end up in fruit waste, which may further aid distribution of ants. Disposal of infested fruit is likely to be by commercial or domestic rubbish systems or where the fruit is consumed.
- Ants are highly mobile and can easily disperse by crawling. Additionally, reproductive males and females are winged and dispersal during mating flights can also occur.

- Many species in the listed genera of ants are attracted to honeydew secreted by sap-sucking hemipterans e.g. mealybugs, aphids, scales and leafhoppers (Fernald 1947; Armbrecht and Ulloa-Chacón 2003; IPPC 2012). These insects are highly polyphagous and are found on a wide variety of host plants across Australia.
- Ants are also attracted to and feed on nursery seedlings, nectar from flowers, resinous secretion (bamboo), pollen and fruiting fungal structures, all of which are readily present throughout Australia (Kalshoven 1981).

The invasive nature of ants, ability to adapt to a wide range of habitats, highly mobile nature and abundant food source (e.g. honeydew excreted by sap-sucking insects, nectar, pollen) support a likelihood estimate for distribution of ‘high’.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probabilities of importation and of distribution using the matrix of rules shown in Table 2.2.

The likelihood that *Camponotus* sp., *Cardiocondyla* sp., *Crematogaster* sp., *Dolichoderus* sp., *Iridomyrmex* sp., *Monomorium* sp., *Paratrechina* sp., *Pheidole* sp., *Plagiolepis* sp., *Polyrhachis* sp., *Tapinoma* sp., *Technomyrmex* sp., *Tetramorium* sp., and *Wasmannia auropunctata* will enter Australia as a result of trade in mangosteen fruit from Indonesia and be distributed in a viable state to a susceptible host is: **HIGH**.

4.7.2 Probability of establishment and of spread

As indicated above, the probability of establishment and of spread for the listed ant species is being based on the assessment for *Wasmannia auropunctata* on limes from New Caledonia (Biosecurity Australia 2006a). The ratings from the previous assessment are presented below:

Probability of establishment:	**MODERATE**
Probability of spread:	**HIGH**

4.7.3 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of ‘rules’ are shown in Table 2.2.

The overall likelihood that the listed ants will enter Australia as a result of trade in mangosteen fruit from Indonesia, be distributed in a viable state to susceptible host, establish in Australia and subsequently spread within Australia: **MODERATE**.

4.7.4 Consequences

The consequences of the establishment of *Technomyrmex butteli* and an unidentified *Dolichoderus* species in Australia have been estimated previously for mangosteens from Thailand as low (DAFF 2004b) and for *Wasmannia auropunctata* for Tahitian limes from New Caledonia as moderate (Biosecurity Australia 2006a). This was presumably due to *W. auropunctata* being a more highly invasive species that is capable of causing a reduction in the productivity of farm workers due to their stinging behaviour, leading to premium wages being paid to workers to work in infested areas as well as being rated amongst 100 of the world's worst invasive alien species (Lowe *et al.* 2000) than either the unidentified *Dolichoderus* species or *Technomyrmex butteli* on Thai mangosteens. This risk assessment takes a conservative approach and rates the consequences for the unidentified ant species and *Wasmannia auropunctata* which is under official control and eradication in Queensland (DEEDI 2011; IPPC 2012) as moderate.

The estimate of impact is provided below. As the ratings were conducted on a scale from A to F, they have been adjusted to reflect a current rating scale from A to G.

Plant life or health	**C**
Any other aspects of the environment	**E**
Eradication, control etc.	**E**
Domestic trade	**E**
International trade	**D**
Environment	**D**

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are considered to be: **MODERATE**.

4.7.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the estimate of consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for *Camponotus* sp., *Cardiocondyla* sp., *Crematogaster* sp., *Dolichoderus* sp., *Iridomyrmex* sp., *Monomorium* sp., *Paratrechina* sp., *Pheidole* sp., *Plagiolepis* sp., *Polyrhachis* sp., *Tapinoma* sp., *Technomyrmex* sp., *Tetramorium* sp. and *Wasmannia auropunctata*	
Overall probability of entry, establishment and spread	Moderate
Consequences	Moderate
Unrestricted risk	Moderate

As indicated, the unrestricted risk estimate for *Camponotus* sp., *Cardiocondyla* sp., *Crematogaster* sp., *Dolichoderus* sp., *Iridomyrmex* sp., *Monomorium* sp., *Paratrechina* sp., *Pheidole* sp., *Plagiolepis* sp., *Polyrhachis* sp., *Tapinoma* sp., *Technomyrmex* sp., *Tetramorium* sp. and *Wasmannia auropunctata* has been assessed as 'moderate', which is above Australia's ALOP. Therefore, specific risk management measures are required for these pests.

4.8 Pest risk assessment conclusions

Key to Table 4.2 (starting next page)

Genus species $^{\textbf{EP}}$	pests for which policy already exists. The outcomes of previous assessments and/or reassessments in this report are presented in Table 4.2
Genus species $^{\text{state/territory}}$	state/territory in which regional quarantine pests have been identified

Likelihoods for entry, establishment and spread

N	negligible
EL	extremely low
VL	very low
L	low
M	moderate
H	high
P[EES]	overall probability of entry, establishment and spread

Assessment of consequences from pest entry, establishment and spread

PLH	plant life or health
OE	other aspects of the environment
EC	eradication, control etc.
DT	domestic trade
IT	international trade
ENC	environmental and non-commercial
A-G	consequence impact scores are detailed in section 2.2.3 A Indiscernible at the local level B Minor significance at the at the local level C Significant at the local level D Significant at the district level E Significant at the regional level F Significant at the national level G Major significance at the national level
URE	unrestricted risk estimate. This is expressed on an ascending scale from negligible to extreme.

Table 4.2 Summary of unrestricted risk estimates for quarantine pests associated with fresh mangosteen fruit from Indonesia

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]								
	Importation	Distribution	**Overall**				Direct		Indirect				**Overall**	
							PLH	**OE**	**EC**	**DT**	**IT**	**ENC**		
Spider mites [Polystigmata: Tetranychidae]														
Tetranychus spp. $^{\text{EP}}$	High	Moderate	Moderate	High	Moderate	Low	E	B	D	C	D	B	Moderate	**Low**
Weevils [Coleoptera: Curculionidae]														
Curculio sp.	High	Low	Low	Low	Moderate	Very low	D	B	D	D	D	B	Low	**Negligible**
Fruit flies [Diptera: Tephritidae]														
Bactrocera carambolae $^{\text{EP}}$	Extremely low	High	Extremely low	High	High	Extremely low	E	C	F	E	E	D	High	**Very low**
Bactrocera papayae $^{\text{EP}}$														
Soft scale [Hemiptera: Coccidae]														
Drepanococcus chiton $^{\text{EP}}$	High	Low	Low	High	High	Low	D	B	C	C	D	B	Low	**Very low**
Armoured scales [Hemiptera: Diaspididae]														
Diaspis boisduvalii $^{\text{WA}}$	High	Low	Low	High	Moderate	Low	D	B	D	C	C	B	Low	**Very low**
Ischnaspis longirostris $^{\text{EP, WA}}$														
Pseudaonidia trilobitiformis $^{\text{EP, WA}}$														
Mealybugs [Hemiptera: Pseudococcidae]														
Dysmicoccus lepelleyi	High	Moderate	Moderate	High	High	Moderate	D	B	D	C	D	B	Low	**Low**
Exallomochlus hispidus														
Hordeolicoccus heterotrichus														
Paracoccus interceptus														
Paraputo odontomachi														

Pest name	**Likelihood of**						**Consequences**							**URE**
	Entry			**Establishment**	**Spread**	**P[EES]**								
	Importation	Distribution	**Overall**				Direct		Indirect				**Overall**	
							PLH	**OE**	**EC**	**DT**	**IT**	**ENC**		
Planococcus lilacinus $^{\text{EP}}$														
Planococcus minor $^{\text{EP, WA}}$	High	Moderate	Moderate	High	High	Moderate	D	B	D	C	D	B	Low	**Low**
Pseudococcus aurantiacus														
Pseudococcus baliteus														
Pseudococcus cryptus $^{\text{EP}}$														
Rastrococcus spinosus $^{\text{EP}}$														
Ants [Hymenoptera: Formicidae]														
Camponotus sp.	High	High	High	Moderate	High	Moderate	C	E	E	E	D	D	Moderate	**Moderate**
Cardiocondyla sp.														
Crematogaster sp.														
Dolichoderus sp. $^{\text{EP}}$														
Iridomyrmex sp.														
Monomorium sp.														
Paratrechina sp.														
Pheidole sp.														
Plagiolepis sp.														
Polyrhachis sp.														
Tapinoma sp.														
Technomyrmex sp. $^{\text{EP}}$														
Tetramorium sp.														
Wasmannia auropunctata $^{\text{EP}}$														

5 Pest risk management

This chapter provides information on the management of quarantine pests identified with an unrestricted risk exceeding Australia's appropriate level of protection (ALOP). The recommended phytosanitary measures are described below.

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 above Australia's ALOP. In calculating the unrestricted risk, existing commercial production practices in Indonesia have been considered, as have post-harvest procedures and the packing of fruit.

In addition to Indonesia's existing commercial production practices for mangosteen fruit and minimum border procedures in Australia, specific pest risk management measures, including operational systems, are proposed to achieve Australia's ALOP.

In this section, DAFF Biosecurity has identified risk management measures that may be applied to consignments of mangosteen fruit sourced from Indonesia. Finalisation of the quarantine conditions may be undertaken with input from the Australian states and territories as appropriate.

Indonesia has proposed the following general framework for the management of pests and procedures for production of mangosteen fruit for export to Australia (IAQA 2008; IAQA 2010; IAQA 2011):

- *Registration*: Mangosteen fruit for export to Australia must originate from orchards and packing houses registered with the Indonesian Agricultural Quarantine Agency (IAQA).
- *Packing house management*: A sanitation program must be carried out in packing houses to ensure they are kept clean. The waste fruit must be collected regularly. The processing line must be specifically used to grade export fruit from registered orchards. Fruit for export to different countries and for the domestic market must not be processed (cleaned and packed) at the same time as fruit processed for export to Australia. IAQA officers or accredited personnel will ensure that all fruit packed for Australia are undamaged and of maturity index 2–3, to comply with the requirement of conditional non-host status of fruit flies.
- *Packaging and labelling*: New and clean cartons or plastic crates must be used for packing fruit. Plant-derived packing materials must not be used, including during the harvesting of fruit. For the convenience of tracing the origin of any problem, all cartons/crates must be labelled 'For Australia', with the reference codes for packing house, lot number, number of cartons/crates in each lot, and date.
- *Storage and transport*: The storage facilities should be clean and hygienic, and windows and doors must be insect-proof. Fruit for export to Australia must be stored separately from fruit destined for other export markets and the domestic market. The quarantine integrity of export fruit to Australia must be maintained during storage and movement. The packing houses must ensure that the relevant records are kept up to date.

- *Pre-export inspection and certification*: IAQA will conduct the phytosanitary inspection and, if the consignment meets the requirements outlined below, issue a phytosanitary certificate.

DAFF Biosecurity has considered the components of Indonesia's proposed general framework. DAFF Biosecurity has also visited mangosteen production areas in Indonesia and observed and collected information related to the framework proposed by Indonesia for registration and management of orchards and packing houses, pest management, storage and transport.

The pest risk management measures recommended by DAFF Biosecurity for the management of identified quarantine pests are based on the mandatory requirement for Indonesia to adhere to existing commercial practices, particularly the packing of undamaged fruit of maturity index 2–3 for export to Australia (refer to Chapter 3).

The recommended pest risk management measures will apply to all the mangosteen production areas from which Indonesia intends to export mangosteen fruit to Australia.

5.1.1 Pest risk management for quarantine pests

The pest risk analysis identified the quarantine pests listed in Table 5.1 as having an unrestricted risk above Australia's ALOP.

This non-regulated analysis builds on the existing policy for mangosteen fruit from Thailand (DAFF 2004b), which includes some of the pests identified in Table 5.1.

This report recommends that when the following pest management practices are followed, the restricted risk for all identified quarantine pests assessed achieves Australia's appropriate level of protection (ALOP). They include:

- a systems approach (cleaning of each individual fruit, including under the calyx, using pressurised air blasting and brushing, fumigation with methyl bromide, and regulatory visual inspection and remedial action) for spider mites, mealybugs and ants
- only undamaged mangosteen fruit at maturity index 2–3 (refer to table 3.4) is to be packed for export to Australia because such fruit does not host fruit flies.

Management for spider mites, mealybugs and ants

Spider mites, *Tetranychus* spp., 11 mealybug species and species of ants from 14 genera were assessed to have an unrestricted risk estimate that exceeds Australia's ALOP. Measures are therefore required to manage these risks.

DAFF Biosecurity proposes the following systems approach based on physical cleaning, methyl bromide fumigation and regulatory visual inspection and remedial action to reduce the risks associated with these arthropod pests to meet Australia‘s ALOP.

Table 5.1 Phytosanitary measures proposed for quarantine pests for fresh mangosteen fruit from Indonesia

Pest	Common name	Measures
Arthropods		
Tetranychus spp.	spider mites	Systems approach: ▪ Cleaning of the fruit, including under the calyx, with pressurised air blasting and brushing ▪ Methyl bromide fumigation or an alternative post harvest phytosanitary treatment approved by DAFF ▪ Regulatory visual inspection by IAQA and remedial action*
Dysmicoccus lepelleyi *Exallomochulus hispidus* *Hordeolicoccus heterotrichus* *Paracoccus interceptus* *Parputo odontomachi* *Planococcus lilacinus* [EP] *Planococcus minor* [EP, WA] *Pseudococcus aurantiacus* *Pseudococcus baliteus* *Pseudococcus cryptus*[EP] *Rastrococcus spinosus*[EP]	mealybugs	
Camponotus sp. *Cardiocondyla sp.* *Crematogaster sp.* *Dolichoderus sp.* [EP] *Iridomyrmex* sp. *Monomorium* sp. *Paratrechina* sp. *Pheidole* sp. *Plagiolepis* sp. *Polyrhachis* sp. *Tapinoma* sp. *Technomyrmex* sp. [EP] *Tetramorium* sp. *Wasmannia auropunctata* [EP]	ants	

*: 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 withdrawing the consignment from export to Australia.

[EP]: Species has been assessed previously and import policy already exists.

[WA]: Pests of regional concern for Western Australia only

Physical cleaning

Mangosteen fruit must be individually cleaned using pressurised air blasting and brushing. Each sepal of the calyx must be carefully lifted and cleaned, first with pressurised air jets, then with a brush, suitable in size to effectively clean under the calyx, to remove any quarantine pests. To prevent reinfestation of fruit, the cleaning area is to be equipped with sticky traps or other approved measures, such as insect zappers and traps.

Methyl bromide fumigation

Methyl bromide fumigation is a measure that is recommended to manage the risk posed by the listed spider mites, mealybugs and ants. The fumigation must take place in Indonesia by an acceptable treatment provider registered by IAQA in accordance with the *AQIS Methyl Bromide Fumigation Standard* (www.daff.gov.au) or equivalent.

All mangosteen consignments are to be fumigated with methyl bromide gas for duration of 2 hours at 32 g/m^3 at a temperature of 21 °C or greater.

The phytosanitary certificate must contain the following fumigation details:

- the name of the fumigation facility
- the date of fumigation
- rate of methyl bromide used, that is initial dosage (g/m^3)
- the fumigation duration (hours) and
- ambient air temperature during fumigation (°C)

Regulatory visual inspection and remedial action

The objective of regulatory visual inspection and remedial action as components of this systems approach is to ensure that any consignments of fresh mangosteen fruit from Indonesia infested with the listed quarantine pests are identified and subjected to appropriate remedial action. The remedial action will reduce the risk associated with spider mites, mealybugs and ants to a very low level to meet Australia's ALOP.

Following mandatory methyl bromide fumigation, a minimum of 600 units of fruit (one unit is one mangosteen fruit), as a representative sample across the entire consignment, must be inspected by IAQA and found free of damaged fruit, quarantine pests and trash (e.g. leaf material, seeds, soil, animal matter/parts or other extraneous material). Each sepal of the calyx must be lifted and inspected for spider mites, mealybugs and ants. All consignmenst must be inspected for any fruit that is damaged, such as cracked skin or puncture marks. Consignments found to fail this requirement will be withdrawn from export to Australia.

Conclusion

The objective of this measure (a systems approach) is to reduce the likelihood of importation for the listed spider mites, mealybugs and ants to at least 'very low'. The restricted risk would then be reduced to at least 'very low', which would achieve Australia's ALOP.

5.1.2 Consideration of alternative measures

Consistent with the principle of equivalence detailed in ISPM 11: *Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms* (FAO 2004), DAFF Biosecurity will consider any alternative measure proposed by IAQA, providing that it achieves an equivalent level of quarantine protection. Evaluation of such measures or treatments will require a technical submission from IAQA that details the proposed measures or treatments, including data from suitable trials to demonstrate efficacy.

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 mangosteen fruit from Indonesia. This is to ensure that the proposed risk management measures have been met and are maintained.

Details of the operational system, or equivalent, will be determined by agreement between DAFF Biosecurity and IAQA.

5.2.1 Audit and verification

The objective of the recommended requirement for audit and verification is to ensure that the agreed biosecurity measures are functioning effectively.

DAFF Biosecurity reserves the right to audit the entire phytosanitary system for mangosteen imports from Indonesia, including packing house processing, mandatory methyl bromide fumigation and pre-export inspection and certification. DAFF Biosecurity reserves the right to conduct these audits before issuing import permits and at any time during the entire production cycle.

5.2.2 Registration of export orchards by IAQA

The objective of this procedure is to ensure that mangosteen fruit is sourced from registered export orchards producing export quality fruit, as the pest risk assessments are based on existing commercial production practices.

It is recommended that participating export orchards be registered before commencement of harvest each season. IAQA should maintain a current list of registered orchards in order to facilitate trace-back of any consignment.

5.2.3 Registration of packing house and treatment providers and auditing of procedures

The objectives of this procedure are to ensure that:

- mangosteen fruit is packed only in registered packing houses, processing export quality fruit, as the pest risk assessments are based on existing commercial packing procedures
- mangosteen fruit are fumigated by a treatment provider registered by IAQA
- references to the packing house (by registration number or reference code and packing house name) are clearly stated on crates destined for export of mangosteen fruit to Australia for trace-back and auditing purposes.

It is recommended that the packing houses and treatment providers be registered before the commencement of harvest each season. IAQA must provide DAFF Biosecurity with a list of registered packing houses and treatment providers prior to season commencement each year and inform DAFF Biosecurity of any changes to registrations during the season. This list must be maintained as current by IAQA in order to facilitate trace-back of any consignment.

Prior to the commencement of each export season, IAQA or an authorised agency should audit registered packing houses and treatment facilities to ensure that that the facilities are suitably equipped to meet Australia's import conditions. The audit should include registration requirements, packing house processes, product handling, product security and delivery of phytosanitary treatments. Records from these audits must be made available to DAFF Biosecurity on request.

5.2.4 Packaging and labelling

The objectives of this recommended procedure are to ensure that:

- mangosteen fruit recommended for export to Australia and all associated packaging is not contaminated by quarantine pests or regulated articles (e.g. trash, soil and weed seeds)
- unprocessed packing material (which may vector pests not identified as being on the pathway) is not imported with fresh mangosteen fruit
- all wood material used in packaging of the commodity complies with AQIS conditions (see AQIS publication *Cargo Containers: Quarantine aspects and procedures*)
- secure packaging is used during storage and transport for export to Australia and must meet Australia's general import conditions for fresh fruits and vegetables (*C6000 General requirements for all fruit and vegetables*, available at http://www.aqis.gov.au/icon/)
- the packaged mangosteen fruit is labelled with the packing house name for the purposes of trace-back
- the phytosanitary status of fruit must be clearly identified.

5.2.5 Specific conditions for storage and movement

The objectives of this recommended procedure are to ensure that:

- product for export to Australia that has been treated and/or inspected is kept secure and segregated at all times from any fruit for domestic or other markets, untreated product to prevent mixing or cross-contamination elsewhere
- the quarantine integrity of the commodity during storage and movement is maintained.

5.2.6 Freedom from trash

All mangosteen fruit must be free from trash (e.g. extraneous stem and leaf material, seeds, soil, animal matter/parts or other extraneous material), foreign matter and pests of quarantine concern to Australia. Freedom from trash will be confirmed by the inspection procedures. Export lots or consignments found to contain trash, foreign matter, or pests of quarantine concern to Australia should be withdrawn from export unless approved remedial action is available and applied to the export consignment.

5.2.7 Pre-export phytosanitary inspection and certification by IAQA

The objectives of this recommended procedure are to ensure that:

- all consignments have been inspected in accordance with official procedures for all visually detectable quarantine pests and other regulated articles (including soil, animal and plant debris) at a standard 600 unit sampling rate per phytosanitary certificate
- each sepal of the calyx must be lifted and inspected for quarantine pests
- consignments that contain live quarantine pests or fruit that is damaged, such as with cracked skin or puncture marks, will be rejected

- an international phytosanitary certificate (IPC) is issued for each consignment upon completion of pre-export inspection and treatment to verify that the relevant measures have been undertaken offshore
- each IPC includes:
    - a description of the consignment (including packing house details)
    - details of disinfestation treatments (e.g. methyl bromide fumigation) which includes date, concentration, temperature, duration, and/or attach fumigation certificate (as appropriate)

  and

    - an additional declaration that '*The fruit in this consignment has been produced in Indonesia in accordance with the conditions governing entry of fresh mangosteen fruit to Australia and inspected and found free of quarantine pests*'.

5.2.8 On-arrival phytosanitary inspection by DAFF Biosecurity

The objectives of this recommended procedure are to ensure that:

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

To ensure that phytosanitary status of consignments of mangosteen fruit from Indonesia meets Australia's import conditions it is recommended that DAFF Biosecurity complete a verification inspection of all consignments of mangosteens. It is recommended that DAFF Biosecurity randomly sample 600 fruit from each consignment for quarantine pests.

DAFF Biosecurity will undertake a documentation compliance examination to verify that the consignment is as described on the phytosanitary certificated, that required phytosanitary actions have been undertaken and that product security has been maintained.

5.2.9 Remedial action(s) for non-compliance

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

- any quarantine risk is addressed by remedial action, as appropriate
- non-compliance with import requirements is addressed, as appropriate.

Any consignment that fails to meet Australia's import conditions must be subject to a suitable remedial treatment, if one is available, re-exported from Australia, or destroyed.

Separate to the corrective measures mentioned above, there may be other breach actions necessary depending on the specific pest intercepted and the risk management strategy put in place against that pest in the protocol.

If product repeatedly fails inspection, DAFF Biosecurity reserves the right to suspend the export program and conduct an audit of the risk management systems. The program will recommence only when DAFF Biosecurity is satisfied that appropriate corrective action has been taken.

5.3 Uncategorised pests

If an organism, including contaminant pests/pathogens, is detected on mangosteen fruit either in Indonesia or on-arrival in Australia that has not been categorised, it will require assessment by DAFF Biosecurity to determine its quarantine status and whether phytosanitary action is required. Assessment is also required if the detected species was categorised as not likely to be on the import pathway. If the detected species was categorised as on the pathway but assessed as having an unrestricted risk that achieves Australia's ALOP due to the rating for likelihood of importation, then it would require reassessment. The detection of any pests of quarantine concern not already identified in the 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 Audit of protocol

Prior to the first season of trade, representatives from DAFF Biosecurity will visit areas in Indonesia that produce mangosteen fruit for export to Australia. They will audit the implementation of agreed import conditions and phytosanitary systems.

5.5 Review of policy

DAFF Biosecurity reserves the right to review the import policy after the first year of trade or when there is reason to believe that the pest or phytosanitary status in Indonesia has changed.

IAQA must inform DAFF Biosecurity immediately on detection in Indonesia of any new pests of mangosteen fruit that are of potential quarantine concern to Australia or a significant change in the application of existing commercial practices considered in this report.

Appendices

Appendix A Initiation and categorisation for pests of fresh mangosteen fruit from Indonesia[5]

Initiation (columns 1 – 3) identifies the pests of mangosteens that have the potential to be on mangosteen fruit produced in Indonesia using commercial production and packing procedures.

Pest categorisation (columns 4 - 7) identifies which of the pests with the potential to be on mangosteen fruit are quarantine pests for Australia and require a pest risk assessment.

The steps in the initiation and categorisation processes are considered sequentially, with the assessment terminating at the first 'No' for columns 3, 5 or 6 or 'Yes' for column 4.

Details of the method used in this report are given in Section 2: Method for pest risk analysis.

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
DOMAIN EUKARYA						
ANIMALIA						
ARTHROPODA: Arachnidia						
Order Prostigmata						
Polyphagotarsonemus latus (Banks, 1904) [Prostigmata: Tarsonemidae] Broad mite	Yes (Waterhouse 1993)	Yes Intercepted in Australia on fresh mangosteen fruit from Thailand.	Yes All states and territories (APPD 2011)	Assessment not required	Assessment not required	No
Tetranychus spp. [Prostigmata: Tetranychidae] Spider mites	Yes (Waterhouse 1993; Migeon and Dorkeld 2010)	Yes *Tetranychus* spp. can attack flowers and feed on fruit surfaces, leaving fruit unsuitable for export (Yaacob and Tindall 1995).	Many species of the genus *Tetranychus* are present in Australia. However, there are also many species that are absent from Australia.	Yes Spider mites have well developed dispersal mechanisms that enable their populations to spread and exploit a wide range of host plants over large areas (Godfrey 2011). For example, *T. kanzawai* has been introduced and established in Queensland.	Yes *Tetranychus* spp. are polyphagous pests (Bolland *et al.* 1998). Some species, including *T. kanzawai*, are subject to quarantine measures in many parts of the world (Navajas *et al.* 2001).	Yes

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[5] This pest categorisation table does not represent a comprehensive list of all the pests associated with the entire plant of an imported commodity. Reference to soilborne nematodes, soiborne pathogens, wood borer pests, root pests or pathogens, and secondary pests have not been listed or have been deleted from the table, as they are not directly related to the export pathway of fresh mangosteen fruit and would be addressed by Australia's current approach to contaminating pests.

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Order Sarcoptiformes						
Afronothrus incisivus Wallwork, 1961 [Sarcoptiformes: Trhypochthoniidae]	Yes Pantropical distribution (Subías 2004)	Yes Intercepted in Australia on fresh mangosteen fruit from Thailand.	Yes (Wang *et al.* 1999; Schatz 2006)	Assessment not required	Assessment not required	No
Tyrophagus javensis (Oudemans, 1916) [Sarcoptiformes: Acaridae] Mould mite	Yes (Fan and Zhang 2007)	Yes Intercepted in Australia on fresh mangosteen fruit from Thailand.	Yes (Fan and Zhang 2007)	Assessment not required	Assessment not required	No
Tyrophagus putrescentiae (Schrank, 1781) [Sarcoptiformes: Acaridae] Mould mite	Yes (Mueller *et al.* 2006)	Yes Intercepted in Australia on fresh mangosteen fruit from Thailand.	Yes (Fan and Zhang 2007)	Assessment not required	Assessment not required	No
ARTHROPODA: Insecta						
Order Coleoptera						
Carpophilus dimidiatus (Fabricius, 1792) [Coleoptera: Nitidulidae] Corn-sap beetle	Yes (Soekarna and Kilin 1981; CABI 2011)	Yes Associated with mangosteen (Yunus and Ho 1980). External feeder on the fruit of hosts (CABI 2011).	Yes All states and territories (CSIRO 2005; APPD 2011)	Assessment not required	Assessment not required	No
Curculio sp. [Coleoptera: Curculionidae] Nut weevils	Yes (Kalshoven 1981)	Yes *Curculio* fruit borers can infest mangosteen fruits and seeds. The larvae attack mangosteen fruit from the mature to ripe stages, and eat the mesocarp, aril and seed (Osman and Milan 2006).	Species of *Curculio* are recorded in Australia (APPD 2011). However, the species assemblage may differ from that in Indonesia.	Yes Mangosteens are grown in Australia and could serve as a host.	Yes *Curculio* sp. may have potential for economic impact on mangosteen production in Australia. No control recommendations are available beyond destroying all affected fruits to reduce the beetle population in the field (Osman and Milan 2006).	Yes

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Endaeus calophylli Marshall, G.A.K., 1923 [Coleoptera: Curculionidae]	Yes (Marshall 1923)	No Feeds on mangosteen leaves and twigs (Yunus and Ho 1980).	No records found	Assessment not required	Assessment not required	No
Hypothenemus hampei (Ferrari, 1867) [Coleoptera: Curculionidae] Coffee berry borer	Yes (Waterhouse 1993)	No One published recorded on mangosteen flowers, as *Cryphalus hampei* (Yunus and Ho 1980). No record of association with mangosteen fruit.	No records found	Assessment not required	Assessment not required	No
Nodina fulvitarsis Jacoby, 1896 [Coleoptera: Chrysomelidae]	Yes (Jacoby 1896)	No Recorded on mangosteen flowers (Yunus and Ho 1980). No record of association with mangosteen fruit.	No records found	Assessment not required	Assessment not required	No
Xylosandrus compactus (Eichhoff, 1875) [Coleoptera: Scolytidae] Shot-hole borer	Yes (CABI 2011)	No Associated with mangosteen in Hawaii. The beetles attack the stems of host plants (USDA-APHIS 2006).	No records found	Assessment not required	Assessment not required	No
Order Diptera						
Bactrocera carambolae Drew & Hancock, 1994 [Diptera: Tephritidae] Carambola fruit fly	Yes (Drew and Hancock 1994)	Yes Infestation of mangosteen fruit by *B. carambolae* has been recorded once (Allwood *et al.* 1999). Intact unbroken fruit is unlikely to host fruit flies due to its thick skin. However, any damaged fruit may host fruit flies.	No records found	Yes *B. carambolae* has a wide host range (Allwood *et al.* 1999). It is dispersed through infested fruit and adult flight. Adult fruit flies can fly up to 50–100 km (Fletcher 1989).	Yes The economic impact to Australia would arise from direct yield losses and quarantine restrictions imposed by important domestic and foreign markets.	Yes

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Bactrocera dorsalis (Hendel, 1912) [Diptera: Tephritidae] Oriental fruit fly	No While some reports list *B. dorsalis* as present in Indonesia, these likely refer to records before the reviews of the *B. dorsalis* species complex. *B. dorsalis sensu stricto* does not appear to be present in Indonesia, while other species within the complex are, including *B. carambolae* and *B. papayae* (Clarke *et al.* 2005; Stephens *et al.* 2007).	Assessment not required	No records found	Assessment not required	Assessment not required	No
Bactrocera papayae Drew & Hancock, 1994 [Diptera: Tephritidae] Papaya fruit fly	Yes (Drew and Hancock 1994; CABI 2011)	Yes *B. papayae* was reared from three mangosteen fruit samples collected in southeast Asia, although the condition of the fruit was not specified (Allwood *et al.* 1999). Intact unbroken fruit is unlikely to host fruit flies due to its thick skin. However, any damaged fruit may host fruit flies.	No current records found Eradicated from Qld.	Yes *B. papayae* has a very wide host range (Allwood *et al.* 1999). It has significant potential to establish and spread as shown by its subsequently managed incursion in north Queensland during the mid-1990s (Cantrell *et al.* 2002).	Yes The economic impact to Australia would arise from direct yield losses and quarantine restrictions imposed by important domestic and foreign markets.	Yes
Drosophila albomicans (Duda, 1923) [Diptera: Drosophilidae] Vinegar fly	Yes (Kahono *et al.* 2010)	No Associated with mangosteen fruit (Yunus and Ho 1980). Adult *Drosophila* spp. feed on rotting/overripe fruit, where they lay their eggs, which hatch into small maggots. Mature undamaged fruit are not attacked (CABI 2011).	No records found	Assessment not required	Assessment not required	No

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Drosophila immigrans Sturtevant, 1921 [Diptera: Drosophilidae] Vinegar fly	Yes Cosmopolitan distribution (Wheeler and Takada 1964)	No Associated with mangosteen fruit (Yunus and Ho 1980). Adult *Drosophila* spp. feed on rotting/overripe fruit, where they lay their eggs, which hatch into small maggots. Mature undamaged fruit are not attacked (CABI 2011).	Yes All states and territories (Bock 1976)	Assessment not required	Assessment not required	No
Drosophila melanogaster Meigen, 1830 Synonym: *Drosophila ampelophila* Loew, 1862 [Diptera: Drosophilidae] Vinegar fly	Yes (CABI 2011)	No Reported on mangosteen as *D. ampelophila* (Yunus and Ho 1980). Associated with overripe or rotting fruit (CABI 2011).	Yes All states and territories (CSIRO 2005; APPD 2011)	Assessment not required	Assessment not required	No
Zaprionus multistriatus Duda, 1923 [Diptera: Drosophilidae]	Yes (Okada and Carson 1983)	No *Zaprionus multistriatus* has been recorded on mangosteen fruit, but the condition of affected fruit is unclear (Yunus and Ho 1980). *Zaprionus* spp. feed on rotting/overripe or fallen fruit. Mature undamaged fruit for harvest are not attacked except by one species, (*Z. indianus*) which attacks immature figs in Brazil and immature guava fruits in Argentina (Lavagnino *et al.* 2008).	No records found	Assessment not required	Assessment not required	No
Order Hemiptera						
Aonidiella aurantii (Maskell, 1879) [Hemiptera: Diaspididae] California red scale	Yes (Ben-Dov 2011c)	Yes Intercepted in Australia on fresh mangosteen fruit from Thailand.	Yes NSW, Vic., Qld, SA, NT, WA (CSIRO 2005; Poole 2010; APPD 2011)	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Aspidiotus destructor Signoret, 1869 [Hemiptera: Diaspididae] Coconut scale	Yes (Kalshoven 1981; Bigger 2009)	No Reported as a pest of mangosteen (Hasyim *et al.* 2006), affecting the leaves (Yunus and Ho 1980). Crawlers feed on the underside of leaves causing yellowing and wilting (Nafus 2000; Watson 2005a).	Yes NSW, NT, Qld, Vic., WA (Hill 2008; Poole 2010; APPD 2011)	Assessment not required	Assessment not required	No
Asterolecanium garciniae Russell, 1941 [Hemiptera: Asterolecaniidae] Star scale	Yes (Russell 1941; Ben-Dov 2011a)	No Associated with the lower surface of mangosteen leaves (Russell 1941).	No records found	Assessment not required	Assessment not required	No
Ceroplastes floridensis Comstock, 1881 [Hemiptera: Coccidae] Florida wax scale	Yes (Ben-Dov 2011b)	No Primarily occurs on stems and leaves (Miller *et al.* 2007), but also reported on fruit of other hosts, e.g. guava (Gould and Raga 2002). No records of association with mangosteen fruit.	Yes NSW, Qld (CSIRO 2005; APPD 2011)	Assessment not required	Assessment not required	No
Ceroplastes rubens Maskell, 1893 [Hemiptera: Coccidae] Pink wax scale	Yes (Ben-Dov 2011b)	No Mangosteen reported as a host (Halbert 2011). *Ceroplastes* spp. are associated with the leaves, leaf stalks and shoots of host plants (Srivastava 1997).	Yes NSW, NT, Qld, Vic., WA (CSIRO 2005; Poole 2010; APPD 2011)	Assessment not required	Assessment not required	No
Chrysomphalus aonidum (Linnaeus, 1758) [Hemiptera: Diaspididae] Black scale or Florida red scale	Yes (Ben-Dov 2011c)	Yes *Garcinia* sp. is a host (Ben-Dov 2011c). *C. aonidum* are associated with the leaves and branches of hosts but can affect fruit during periods of very heavy infestation (CABI 2011).	Yes Qld, NSW, NT, Tas., WA (CSIRO 2005; APPD 2011)	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Coccus viridis (Green, 1889) [Hemiptera: Coccidae] Florida wax scale	Yes (Ben-Dov 2011b)	No Intercepted on mangosteen material from Hawaii (USDA-APHIS 2006). No records of association with mangosteen fruit.	Yes NSW, NT, Qld, WA (Poole 2010; APPD 2011)	Assessment not required	Assessment not required	No
Diaspis boisduvalii Signoret, 1869 [Hemiptera: Diaspididae] Boisduval scale	Yes (Tjoa 1960)	Yes Occurs on all aerial plant parts (leaves, fruit and stems) of host plants (Tenbrink and Hara 1992a; Miller and Davidson 2005b).	Yes Vic., NSW, Tas., Qld, SA (CSIRO 2005; APPD 2011) Not present in WA (Poole 2010)	Yes Dispersed as first-instar nymphs (Magsig-Castillo *et al.* 2010), has a wide host range and is near-cosmopolitan (Miller and Davidson 2005b). Climates in parts of Western Australia would be suitable for the establishment *D. boisduvalii.*	Yes Important pest of orchids (Miller and Davidson 2005b). Also a minor pest of bananas, pineapples, coffee, and coconuts (Miller and Davidson 2005b).	Yes (WA)
Drepanococcus chiton (Green 1909) [Hemiptera: Coccidae] Wax scale	Yes (Ben-Dov 2011b)	Yes *Drepanococcus* sp. has been intercepted in Australia on mangosteen fruit from Thailand. Given the distribution records of the genus, the species is almost certainly *D. chiton.*	No records found	Yes Highly polyphagous, and has been found living on plant species from various genera (Ben-Dov and Hodgson 1997). Found in Asian countries with environments similar to areas in Australia.	Yes Coccidae consume large quantities of plant sap. This can result in a loss of plant vigour, poor growth, dieback, early leaf drop and sometimes death of the entire plant. During feeding, they inject saliva into the plant that can be toxic, produce chlorotic discolouration and deformation. The honeydew they excrete also causes the growth of sooty mould, which interferes with photosynthesis, can cause a reduction in fruit size and generally gives the crop an unsightly appearance (Gill and Kosztarab 1997).	Yes

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Dysmicoccus lepelleyi (Betrem, 1937) [Hemiptera: Pseudococcidae] Annona mealybug	Yes (Ben-Dov 2011d)	Yes Has been intercepted in the US on mangosteen fruit (Williams 2004).	No records found	Yes Has a wide host range (Ben-Dov 2011d) and susceptible hosts are present in Australia	Yes A polyphagous species (Williams 2004). Mealybugs feed on sap, stressing their host plants and reducing the yield of commercial crops. The production of honeydew by mealybugs also promotes the growth of sooty moulds, which reduces the marketability of fruit (CABI 2011).	Yes
Exallomochlus hispidus (Morrison, 1921) [Hemiptera: Pseudococcidae] Cocoa mealybug	Yes (Williams 2004; Bigger 2009)	Yes Associated with the stems and fruits of host plants (Ben-Dov 2011d). Has been intercepted in the US and Europe on mangosteen (Williams 2004)	No records found	Yes Has a wide host range (Ben-Dov 2011d) and susceptible hosts are present in Australia. Found in Asian countries with environments similar to areas in Australia.	Yes A polyphagous species. Although there is no evidence that this species causes economic loss, the cosmetic appearance of fruit is affected by the presence of mealybugs and associated sooty mould (Williams 2004)	Yes
Helopeltis antonii Signoret, 1858 [Hemiptera: Miridae]	Yes (Siswanto *et al.* 2008; Directorate General of Horticulture 2010)	No Infests the fruits and leaves of mangosteen (Directorate General of Horticulture 2010). Infestation of fruit is limited to immature fruit, which then shrivel, die and fall from the tree (Stonedahl 1991; Siswanto *et al.* 2008; CABI 2011)	No records found	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Helopeltis bradyi Waterhouse, 1886 [Hemiptera: Miridae]	Yes (Bigger 2009)	No Although *H. bradyi* has not been recorded as a pest of mangosteen, Stonedahl (1991) states that it is highly likely that at least some of the published information on *H. antonii* actually pertains to *H bradyi* due to the close resemblance between the two species.	No records found	Assessment not required	Assessment not required	No
Hemiberlesia lataniae (Signoret,1869) [Hemiptera: Diaspididae] Latania scale	Yes (Ben-Dov 2011c)	Yes *Garcinia* sp. reported as a host (Ben-Dov 2011c). Feeds on foliage and fruits (Peña and Mohyuddin 1997)	Yes NSW, NT, Qld, Vic., WA (CSIRO 2005; APPD 2011)	Assessment not required	Assessment not required	No
Hordeolicoccus heterotrichus (Williams, 2004) [Hemiptera: Pseudococcidae] Citrus mealybug	Yes (Ben-Dov 2011d)	Yes Has been intercepted in the US on mangosteen (Williams 2004).	No records found	Yes Has a wide host range (Ben-Dov 2011d) and susceptible hosts are present in Australia such as rambutan and mangosteen.	Yes A polyphagous species (Williams 2004). Mealybugs feed on sap, stressing their host plants and reducing the yield of commercial crops. The production of honeydew by mealybugs also promotes the growth of sooty moulds, which reduces the marketability of fruit (CABI 2011).	Yes
Icerya seychellarum (Westwood, 1855) [Hemiptera: Margarodidae] Seychelles scale	Yes (Hill 2008; CABI 2011)	No Infests the leaves and stems of a range of commercial plants, including mangosteen (CABI 2011). No records of association with mangosteen fruit.	Yes NSW, NT, Qld (APPD 2011)	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Ischnaspis longirostris (Signoret, 1882) [Hemiptera: Diaspididae] Black thread scale	Yes (Miller *et al.* 2011)	Yes *Garcinia* sp. reported as a host (Watson 2005b; Miller *et al.* 2011). Usually attacks leaves but occasionally bark and fruit (Watson 2005b)	Yes NT, Qld (APPD 2011) Not present in WA (Poole 2010)	Yes Has a wide host range (Williams and Watson 1988a) and is already established in northern Australia (APPD 2011). Can be dispersed by wind and plant material (Beardsley and Gonzalez 1975).	Yes It is considered an important pest in Malaysia, Brazil and the US (Watson 2005b).	Yes (WA)
Maconellicoccus hirsutus (Green, 1908) [Hemiptera: Pseudococcidae] Grape mealybug	Yes (Ben-Dov 2011d)	Yes Associated with mangosteen in Hawaii and it attacks the leaf, stem, flower and fruit (USDA-APHIS 2006).	Yes NT, Qld, SA, Vic, WA (APPD 2011; Ben-Dov 2011d)	Assessment not required	Assessment not required	No
Maconellicoccus multipori (Takahashi, 1951) [Hemiptera: Pseudococcidae] Pink hibiscus mealybug	Yes (Ben-Dov 2011d)	No *Garcinia* sp. reported as a host (Ben-Dov 2011d). Feeds on the roots of host plants (Williams 2004).	No records found	Assessment not required	Assessment not required	No

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Paracoccus interceptus Lit, 1997 [Hemiptera: Pseudococcidae] Intercepted mealybug	Yes (Williams 2004)	Yes Has been intercepted in the US on mangosteen (Williams 2004)	No records found	Yes Has a wide host range (Ben-Dov 2011d) and susceptible hosts are present in Australia.	Yes Williams (2004) states that *P. interceptus* must be regarded as a possible invasive species as it is frequently intercepted by quarantine inspections in the US. Mealybugs feed on sap, stressing their host plants and reducing the yield of commercial crops. The production of honeydew by mealybugs also promotes the growth of sooty moulds, which reduces the marketability of fruit (CABI 2011).	Yes

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Paraputo odontomachi (Takahashi, 1951) [Hemiptera: Pseudococcidae]	Yes (Williams 2004)	Yes Has been intercepted in the US on mangosteen (Williams 2004).	No records found	Yes Has a wide host range (Ben-Dov 2011d) and susceptible hosts are present in Australia.	Yes Williams (2004) states that *P. odontomachi* must be regarded as a possible invasive species as it is frequently intercepted by quarantine inspections in the US. This species is not known to cause any damage but it is protected by ants and has a wide distribution in southern Asia on economically important plants (Williams 2004). Mealybugs feed on sap, stressing their host plants and reducing the yield of commercial crops. The production of honeydew by mealybugs also promotes the growth of sooty moulds, which reduces the marketability of fruit (CABI 2011).	Yes
Parlatoria ziziphi (Lucas, 1853) [Hemiptera: Diaspididae] Black parlatoria scale	Yes (Ben-Dov 2011c)	No Feeds exclusively on citrus and is rarely recorded on other hosts (Fasulo and Brooks 1993). Although it has been recorded on mangosteen in Hawaii, the host range of this species appears to be restricted to Rutaceae and records from other hosts are questionable (Blackburn and Miller 1984; USDA-APHIS 2006).	No current records found Eradicated from NT	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Planococcus citri (Rissol, 1813) [Hemiptera: Pseudococcidae] Citrus mealybug	Yes (Bigger 2009)	Yes Highly polyphagous in the tropical and subtropical regions (Kalshoven 1981). Found on mangosteen fruit, stems and flowers(Astridge 1998).	Yes All states and territories (CSIRO 2005; APPD 2011)	Assessment not required	Assessment not required	No
Planococcus lilacinus (Cockerell,1905) [Hemiptera: Pseudococcidae] Coffee mealybug	Yes (Ben-Dov 2011d)	Yes Has been intercepted in the US on mangosteen (USDA-APHIS 2006).	No records found	Yes Has a wide host range including several garden ornamentals (Ben-Dov 2011d). Easily dispersed by wind and plant material (Williams and Watson 1988b).	Yes A serious pest of cocoa (Cox 1989) causing severe damage to young trees by killing the tips of branches. It is such an important pest of coffee, cocoa, custard apples, coconuts and mandarins in parts of India that chemical control is warranted (CABI 2011; Ben-Dov 2011d).	Yes
Planococcus minor (Maskell, 1897) [Hemiptera: Pseudococcidae] Pacific mealybug	Yes (Ben-Dov 2011d)	Yes Has been intercepted in the US on mangosteen (USDA-APHIS 2006).	Yes NSW, NT, SA, Qld (CSIRO 2005; APPD 2011) Not present in WA (Poole 2010)	Yes Has a wide host range across more than 60 plant families (Ben-Dov 2011d). Easily dispersed by wind and plant material (Williams and Watson 1988b).	Yes A pest of numerous crops (Venette and Davis 2004) and a serious pest of cocoa (Cox 1989); causing severe damage to young trees by killing the tips of the branches.	Yes (WA)

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Pseudaonidia trilobitiformis (Green, 1896) [Hemiptera: Diaspididae] Cashew scale	Yes (Ben-Dov 2011c)	Yes Has been intercepted in the US on mangosteen (USDA-APHIS 2006).	Yes NT, Qld (APPD 2011) Not present in WA (Poole 2010)	Yes Has a wide host range with hosts recorded from 42 plant families, but host range is probably wider (Watson 2005c). Easily dispersed by wind, plant material or fruit pickers (Williams and Watson 1988a).	Yes Causes significant economic damage to *Citrus*, cashew and cocao (Watson 2005c). Furthermore, hard scales cause a range of damage to their host plants including: chlorosis; discolouration of fruit; shoot, leaf and branch deformation; galls; necrosis of cambial tissues; and deformation, discolouration and abortion of fruit (Kosztarab 1990).	Yes (WA)
Pseudococcus aurantiacus Williams, 2004 [Hemiptera: Pseudococcidae] Orange-coloured mealybug	Yes (Williams 2004)	Yes Has been intercepted in the US on mangosteen (Williams 2004).	No records found	Yes Has a wide host range (Ben-Dov 2011d) and susceptible hosts are present in Australia.	Yes A polyphagous species that is regularly intercepted on fruit in international trade (Williams 2004). Mealybugs feed on sap, stressing their host plants and reducing the yield of commercial crops. The production of honeydew by mealybugs also promotes the growth of sooty moulds, which reduces the marketability of fruit (CABI 2011).	Yes

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Pseudococcus baliteus Lit, 1994 [Hemiptera: Pseudococcidae] Aerial root mealybug	Yes (Williams 2004)	Yes Has been intercepted in the US on mangosteen (Williams 2004).	No records found	Yes Has a wide host range (Ben-Dov 2011d) and susceptible hosts are present in Australia.	Yes A polyphagous species affecting various fruit trees (Williams 2004). Mealybugs feed on sap, stressing their host plants and reducing the yield of commercial crops. The production of honeydew by mealybugs also promotes the growth of sooty moulds, which reduces the marketability of fruit (CABI 2011).	Yes
Pseudococcus cryptus Hempel, 1918 [Hemiptera: Pseudococcidae] Citriculus mealybug; cryptic mealybug	Yes (Williams 2004)	Yes Has been intercepted in the US on mangosteen (Williams 2004).	No records found	Yes Has a wide host range with hosts across 41 families (Ben-Dov 2011d). Widely distributed in South-east Asia, tropical Africa, mid-eastern Mediterranean and South America (Ben-Dov 2011d) with environments similar to those in Australia.	Yes A pest of citrus (Williams 2004).	Yes
Pseudococcus longispinus (Targiono Tozzetti, 1867) [Hemiptera: Pseudococcidae] Long tailed mealybug	Yes (Williams 2004)	Yes Has been intercepted in the US on mangosteen (Williams 2004).	Yes All states and territories (Williams 2004; CSIRO 2005; APPD 2011)	Assessment not required	Assessment not required	No
Pseudococcus viburni (Signoret, 1875) [Hemiptera: Pseudococcidae] Obscure mealybug	Yes (Ben-Dov 2011d)	Yes Has been recorded on mangosteen in Hawaii attacking the fruit (USDA-APHIS 2006).	Yes All states and territories (CSIRO 2005; APPD 2011)	Assessment not required	Assessment not required	No

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Pulvinaria psidii Maskell, 1893 [Hemiptera: Coccidae] Green shield scale	Yes (Ben-Dov 2011b)	Yes Mainly occurs on leaves and stems of woody hosts (CABI 2011). Sometimes occurs on fruit where the crawlers excrete honeydew causing sooty mould to grow on the fruit (CABI 2011).	Yes NSW, NT, Qld (APPD 2011)	Assessment not required	Assessment not required	No
Rastrococcus spinosus (Robinson, 1918) [Hemiptera: Pseudococcidae] Philippine mango mealybug; mango mealybug	Yes (Williams 2004)	Yes Has been intercepted in the US on mangosteen (Williams 2004).	No records found	Yes Has several hosts including mango, citrus, coffee and cashew (Maynard *et al.* 2004). These hosts are grown across Australia.	Yes A pest of economic significance on mango and citrus in West Africa (Williams 2004), and on mango in Pakistan (Mahmood *et al.* 1983).	Yes
Saissetia coffeae (Walker, 1852) [Hemiptera: Coccidae] Brown scale	Yes (Ben-Dov 2011b)	Yes May affect fruit of host plants (Martin Kessing *et al.* 2007). *Garcinia* sp. reported as a host (Ben-Dov 2011b).	Yes All states and territories (CSIRO 2005; APPD 2011)	Assessment not required	Assessment not required	No
Toxoptera aurantii (Boyer de Fonscolombe, 1841) [Hemiptera: Aphididae] Black citrus aphid	Yes (Bigger 2009)	No Associated with the leaves (Yunus and Ho 1980) and commonly found on young shoots and petioles of host plants (Kalshoven 1981).	Yes Qld, NSW, Vic., Tas., WA (CSIRO 2005; Poole 2010)	Assessment not required	Assessment not required	No
Vinsonia stellifera (Westwood, 1871) [Hemiptera: Coccidae] Stellate scale	Yes (Kalshoven 1981)	No Associated with the leaves of host plants, including mangosteen (Kalshoven 1981).	Yes NT (APPD 2011)	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Order Hymenoptera						
Camponotus sp. [Hymenoptera: Formicidae]	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Camponotus* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Camponotus* is present in Australia, some individual species may not be present in Australia (CSIRO 2005).	Yes Ants can establish and spread in Australia; other species in the assessed genera are already present (CSIRO 2011). Ants are highly adaptive, competitive and are general predators or scavengers, feeding on a wide range of prey including other arthropods and seeds (CSIRO 2011).	Yes Invasive ants may alter an ecosystem by interfering with mutualistic relationships. Invasive ant species will compete for resources with native species (GISD 2010). Ants can cause indirect damage through proliferation of honeydew secreting pests. The potential impact on native invertebrates in regions lacking native predacious ants is particularly great and invasive ants have been implicated in the decline of many non-ant invertebrates (GISD 2010).	Yes
Cardiocondyla sp. [Hymenoptera: Formicidae]	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Cardiocondyla* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Cardiocondyla* is present in Australia, some individual species may not be present in Australia (CSIRO 2005).			
Crematogaster sp. [Hymenoptera: Formicidae]	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Crematogaster* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Crematogaster* is present in Australia, some individual species may not be present in Australia (CSIRO 2005).			
Dolichoderus sp. [Hymenoptera: Formicidae] Black ants	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Dolichoderus* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Dolichoderus* is present in Australia, some individual species may not be present in Australia (AntWeb 2011).			
Iridomyrmex sp. [Hymenoptera: Formicidae]	Yes (AntWeb 2011)	Yes *Iridomyrmex* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Iridomyrmex* is present in Australia, some individual species may not be present in Australia (AntWeb 2011).			

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Monomorium sp. [Hymenoptera: Formicidae]	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Monomorium* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Monomorium* is present in Australia, some individual species may not be present in Australia (AntWeb 2011).			
Oecophylla smaragdina (Fabricius, 1775) [Hymenoptera: Formicidae] Green tree ant	Yes (Rizali *et al.* 2008)	Yes *Oecophylla smaragdina* has been intercepted on mangosteen from Thailand to Australia.	Yes NT, Qld, WA (CSIRO 2005; Poole 2010)			
Paratrechina sp. [Hymenoptera: Formicidae]	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Paratrechina* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Paratrechina* is present in Australia, some individual species may not be present in Australia (AntWeb 2011).			
Pheidole sp. [Hymenoptera: Formicidae]	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Pheidole* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Pheidole* is present in Australia, some individual species may not be present in Australia (AntWeb 2011).			
Plagiolepis sp. [Hymenoptera: Formicidae]	Yes (Rizali *et al.* 2008)	Yes *Plagiolepis* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Plagiolepis* is present in Australia, some individual species may not be present in Australia (CSIRO 2011)			
Polyrhachis sp. [Hymenoptera: Formicidae]	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Polyrhachis* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Polyrhachis* is present in Australia, some individual species may not be present in Australia (AntWeb 2011).			

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Tapinoma sp. [Hymenoptera: Formicidae] Ghost ant	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Tapinoma* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Tapinoma* is present in Australia, some individual species may not be present in Australia (AntWeb 2011).			
Technomyrmex sp. [Hymenoptera: Formicidae] Black ants	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Technomyrmex* sp. including *Technomyrmex albipes* has been intercepted on mangosteen from Thailand to Australia.	While the genus *Technomyrmex* is present in Australia, some individual species may not be present in Australia (AntWeb 2011).			
Tetramorium sp. [Hymenoptera: Formicidae]	Yes (Ito *et al.* 2001; Rizali *et al.* 2008)	Yes *Tetramorium* sp. has been intercepted on mangosteen from Thailand to Australia.	While the genus *Tetramorium* is present in Australia, some individual species may not be present in Australia (AntWeb 2011).			
Wasmannia auropunctata (Roger, 1863) [Hymenoptera: Formicidae] Electric ant; Little fire ant	Yes (Wetterer and Porter 2003)	Yes Has been recorded on mangosteen in Hawaii, and it attacks the leaf, stem, and fruit (USDA-APHIS 2006).	Yes. A declared pest and under official control in Qld (Windle 2011). Quarantine pest for Tas. (DPIPWE 2009).			
Order Lepidoptera						
Adoxophyes privatana (Walker, 1863) [Lepidoptera: Tortricidae] Apple leaf-curling moth	Yes (Kalshoven 1981; Waterhouse 1993)	No Rolls the leaves of mangosteen (Robinson *et al.* 2001).	No records found	Assessment not required	Assessment not required	No
Aetholix flavibasalis Guenée 1854 [Lepidoptera: Crambidae]	Yes (Ades and Kendrick 2004)	No Rolls the leaves of mangosteen (Robinson *et al.* 2001).	Yes (ABRS 2009)	Assessment not required	Assessment not required	No
Argyroploce sp. [Lepidoptera: Tortricidae]	Yes (Brown *et al.* 2008)	No Associated with mangosteen leaves (Yunus and Ho 1980).	No records found	Assessment not required	Assessment not required	No
Acrocercops sp. [Lepidoptera: Gracillariidae]	Yes (de Prins and de Prins 2010)	No Associated with mangosteen leaves (Robinson *et al.* 2001).	No records found	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Cydia sp. [Lepidoptera: Tortricidae]	Yes (de Meijere 1938; CABI 2011)	No *Garcinia mangostana* recorded as a host (Robinson *et al.* 2010). No records of association with mangosteen fruit.	No records found	Assessment not required	Assessment not required	No
Dudua aprobola (Meyrick 1886) [Lepidoptera: Tortricidae]	Yes (Ades and Kendrick 2004) (Meijerman and Ulenberg 2004)	No Rolls the leaves of mangosteen (Robinson *et al.* 2001).	Yes (Ades and Kendrick 2004; ABRS 2009)	Assessment not required	Assessment not required	No
Eudocima fullonia (Clerck, 1764) [Lepidoptera: Noctuidae] Fruit piercing moth	Yes (Hill 2008)	No Has been recorded on mangosteen in Hawaii with the adults attacking the fruit (USDA-APHIS 2006).	Yes (Reddy *et al.* 2007; Poole 2010)	Assessment not required	Assessment not required	No
Gatesclarkeana idia Diakonoff, 1973 [Lepidoptera: Tortricidae]	Yes (Ades and Kendrick 2004)	No Attacks flowers of mangosteen (Robinson *et al.* 2001).	Yes (Ades and Kendrick 2004; ABRS 2009)	Assessment not required	Assessment not required	No
Homona eductana (Walker, 1863) [Lepidoptera: Tortricidae]	Yes (Ades and Kendrick 2004)	No Rolls the leaves of mangosteen (Robinson *et al.* 2001).	No records found	Assessment not required	Assessment not required	No
Hyposidra talaca Walker, 1860 [Lepidoptera: Geometridae] Leaf-eating looper	Yes (Kalshoven 1981; Waterhouse 1993; Bigger 2009)	No Associated with the leaves of mangosteen (Waterhouse 1993; Bigger 2009)	Yes (Nielsen *et al.* 1996)	Assessment not required	Assessment not required	No
Lobesia genialis Meyrick, 1912 [Lepidoptera: Tortricidae]	Yes (Ades and Kendrick 2004)	No Infests mangosteen flowers (Robinson *et al.* 2001).	No records found	Assessment not required	Assessment not required	No
Orgyia postica Meyrick, 1912 [Lepidoptera: Lymantriidae] Cocoa tussock moth	Yes (van Eecke 1928; Wakamura *et al.* 2005)	No Infests mangosteen flowers (Robinson *et al.* 2001). The larvae cause serious damage to the young leaves and can cause total defoliation, killing or stunting the tree (Sanchez and Laigo 1968).	No records found	Assessment not required	Assessment not required	No

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Pagodiella hekmeyeri Heylaerts, 1885 [Lepidoptera: Psychidae]	Yes (Bernaed 1919; Van der Meer Mohr 1927)	No Associated with the leaves of mangosteen (Robinson *et al.* 2001; Robinson *et al.* 2010).	No records found	Assessment not required	Assessment not required	No
Phyllocnistis citrella Stainton, 1856 [Lepidoptera: Gracillariidae] Citrus leaf miner	Yes (Waterhouse 1993; Hasyim *et al.* 2006)	No Associated with the leaves and shoots (Yunus and Ho 1980; Osman and Milan 2006; Hasyim *et al.* 2006). Eggs are laid singly on young leaves and the larvae mine the leaf epidermis causing leaf deformation which often leads to early leaf fall (Ooi *et al.* 2002).	Yes (Nielsen *et al.* 1996; Smith *et al.* 1997)	Assessment not required	Assessment not required	No
Stictoptera columba Walker, 1856 [Lepidoptera: Noctuidae] Leaf-eating caterpillar	Yes (Ooi *et al.* 2002)	No Feeds on the young leaves of mangosteen trees (Ooi *et al.* 2002).	No records found	Assessment not required	Assessment not required	No
Stictoptera cucullioides Guenée, 1852 [Lepidoptera: Noctuidae] Leaf-eating caterpillar	Yes (Ooi *et al.* 2002; Hasyim *et al.* 2006)	No Feeds on the young leaves of mangosteen trees (Nagao *et al.* 2004), causing damage to emerging leaves and shoot tips (Osman and Milan 2006).	No records found	Assessment not required	Assessment not required	No
Stictoptera grisea Moore, 1868 [Lepidoptera: Noctuidae] Leaf-eating caterpillar	Yes (Holloway 1985)	No Larvae feed on the leaves of mangosteen trees causing defoliation (Mathur and Singh 1960; Robinson *et al.* 2001).	No records found	Assessment not required	Assessment not required	No
Stictoptera signifera Walker, 1857 [Lepidoptera: Noctuidae] Leaf-eating caterpillar	Yes (Ooi *et al.* 2002)	No Feeds on the young leaves of mangosteen trees (Ooi *et al.* 2002).	No records found	Assessment not required	Assessment not required	No

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Tetramoera schistaceana (Snellen, 1851) [Lepidoptera: Tortricidae] Sugarcane shoot borer; white borer	Yes (Ruinard 1958; CABI 2011)	No Robinson *et al.* (2010) reported *T. schistaceana* as a pest of mangosteen, but the pest appears to be specific to sugarcane (BSES Limited 2011).	No records found	Assessment not required	Assessment not required	No
Order Thysanoptera						
Caliothrips striatopterus (Kobus,1893) [Thysanoptera: Thripidae]	Yes (ABRS 2009)	No Recorded as a pest of mangosteen (Pableo and Velasco 1994). No records of association with the mangosteen fruit.	Yes NSW, NT, Qld, WA (ABRS 2009; Poole 2010)	Assessment not required	Assessment not required	No
Heliothrips haemorrhoidalis (Bouché, 1833) [Thysanoptera: Thripidae] Greenhouse thrips	Yes (Idham *et al.* 2009)	No Feeds on buds of mangosteen (Idham *et al.* 2009).	Yes All states and territories (APPD 2011)	Assessment not required	Assessment not required	No
Megalurothrips usitatus (Bagnall,1913) [Thysanoptera: Thripidae] Bean flower thrips	Yes (APEC Agricultural Technical Cooperation Working Group 2008)	No Mainly feeds on various flowering plants of the family Fabaceae (CABI 2011). No records of association with the mangosteen fruit.	Yes NSW, NT, Qld, WA (Poole 2010; APPD 2011)	Assessment not required	Assessment not required	No
Nesothrips propinquus (Bagnall, 1916) [Thysanoptera: Phlaeothripidae]	Yes (Idham *et al.* 2009)	No Feeds on buds of mangosteen (Idham *et al.* 2009).	Yes NSW, Qld, Tas., Vic., WA (APPD 2011)	Assessment not required	Assessment not required	No
Scirtothrips dorsalis (Hood, 1919) [Thysanoptera: Thripidae] Chilli thrips	Yes (Affandi and Emilda 2009)	Yes Occurs on leaves and infests fruits at early stages. Causes scarring of mangosteen fruit (Affandi and Emilda 2009).	Yes NT, Qld, NSW, WA (Mound 1996; Poole 2010; APPD 2011)	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Selenothrips rubrocinctus Giard, 1901 [Thysanoptera: Thripidae] Red-banded thrips	Yes (APEC Agricultural Technical Cooperation Working Group 2008; Affandi and Emilda 2009)	Yes Causes scarring on mangosteen fruit (Affandi and Emilda 2009). The preferred feeding site is the undersurface of leaves, but in severe infestations fruit is also attacked (Astridge and Fay 2005).	Yes NT, Qld, SA, WA (Poole 2010; APPD 2011)	Assessment not required	Assessment not required	No
Thrips hawaiiensis (Morgan, 1913) [Thysanoptera: Thripidae] Flower thrips	Yes (Bigger 2009)	Yes *Thrips hawaiiensis* has been reported on mangosteen (Pola 2009). *Thrips* spp. attack flowers and feed on fruit surfaces leaving fruit unsuitable for export (Yaacob and Tindall 1995).	Yes Qld, NT, NSW, WA (CSIRO 2005; ABRS 2009; Poole 2010)	Assessment not required	Assessment not required	No
Thrips tabaci (Lindmann, 1888) [Thysanoptera: Thripidae] Onion thrips	Yes (Talekar 1991)	Yes *Thrips tabaci* has been intercepted on mangosteen from Thailand to Australia.	Yes All states and territories (APPD 2011)	Assessment not required	Assessment not required	No
DOMAIN FUNGI						
Class Agaricomycetes						
Order Agaricales						
Marasmius crinis-equi F. Muell. ex Kalchbr. [Agaricales: Marasmiaceae] Horse hair blight	Yes (Hasyim 2006; CABI 2011)	No Associated with leaves and causes dieback of shoots and branches (Lim and Sangchote 2003; CABI 2011).	Yes Qld, Vic., Tas., WA (Robinson and Tunsell 2009; Gates 2009; APPD 2011)	Assessment not required	Assessment not required	No
Marasmiellus scandens (Massee) Dennis & D.A. Reid [Agaricales: Marasmiaceae] White thread blight	Yes (Hasyim 2006; CABI 2011)	No Associated with leaves, twigs and branches (Lim and Sangchote 2003; Hasyim 2006; CABI 2011).	No records found	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Order Corticiales						
Corticium koleroga (Cooke) Höhn. [Corticiales: Corticiaceae] Thread blight	Yes (Lim and Sangchote 2003)	No Infects leaves and young fruits of trees in shaded and humid areas (Almeyda and Martin 1976; Yaacob and Tindall 1995). Filaments covering the infected fruit are highly visible (Almeyda and Martin 1976). Visibly damaged and unsightly fruits will be removed during packing.	No Various records of *Corticium* sp. and two records of *Pellicularia* sp. are recorded from Australia (APPD 2011).	Assessment not required	Assessment not required	No
Order Hymenochaetales						
Phellinus noxius (Corner) G. Cunn. [Hymenochaetales: Hymenochaetaceae] Brown rot	Yes (Farr and Rossman 2011)	No Occurs on roots and stems (Singh 1980; Yaacob and Tindall 1995).	Yes NSW, Qld (APPD 2011)	Assessment not required	Assessment not required	No
Order Polyporales						
Ganoderma philippii (Bres. & Henn. ex Sacc.) Bres. [Polyporales: Ganodermataceae] Red root	Yes (FAO 2007a)	No Causes red root. Survives in the soil on decaying wood and stumps and spreads via its rhizomorph from diseased roots and stumps to healthy roots and stumps (Lim and Sangchote 2003).	No records found	Assessment not required	Assessment not required	No
Phanerochaete salmonicolor (Berk. & Broome) Jülich [Polyporales: Phanerochaetaceae] Pink disease	Yes (Lim and Sangchote 2003; Hasyim *et al.* 2006)	No Pinkish white mycelial threads encompass branches and shoots. The leaves above the zone of infection wilt, dry, and die (Lim and Sangchote 2003; Osman and Milan 2006).	Yes NSW, NT, Qld (May *et al.* 2003; Lim and Sangchote 2003; APPD 2011)	Assessment not required	Assessment not required	No

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Class Dothideomycetes						
Order Botryosphaeriales						
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. Teleomorph: *Botryosphaeria rhodina* (Berk. & M.A. Curtis) Arx [Botryosphaeriales: Botryosphaeriaceae] Stem end rot	Yes (CABI 2011)	Yes A post-harvest rot, occurring on the fruit, flower, leaf, root, seed and stem (Osman and Milan 2006; CABI 2011).	Yes NSW, NT, Qld, SA, WA (APPD 2011)	Assessment not required	Assessment not required	No
Macrophomina phaseolina (Tassi) Goid. [Botryosphaeriales: Botryosphaeriaceae] Charcoal rot; crown rot	Yes (Farr and Rossman 2011)	Yes Occurs on leaves, plant debris, seed, soil, stem and root (Farr and Rossman 2011).	Yes All states and territories except Tas. (APPD 2011)	Assessment not required	Assessment not required	No
Neofusicoccum ribis (Slippers, Crous & M.J. Wingf.) Crous, Slippers & A.J.L Phillips Teleomorph: *Botryosphaeria ribis* Grossenb. & Duggar [Botryosphaeriales Botryosphaeriaceae]	Yes (CABI 2011)	No Stem canker on mangosteen (IPTEKnet 2005)	Yes Qld, WA, ACT, Vic., NSW (APPD 2011)	Assessment not required	Assessment not required	No
Order Dothideales						
Brooksia tropicalis Hansf. [Dothideales: Incertae sedis] Sooty mould	Yes (Robert *et al.* 2005)	No The fungus survives on honeydew produced by insects and in turn produces black sooty films or mould on mangosteen leaves and petioles (Lim and Sangchote 2003).	Yes (Farr and Rossman 2011)	Assessment not required	Assessment not required	No
Order Mycosphaerellales						
Mycosphaerella sp. [Mycosphaerellales: Mycosphaerellaceae] Leaf spot	Yes (Farr and Rossman 2011)	No Associated with the leaves (Singh 1980); causes leaf spots and stem cankers (Crous *et al.* 2000).	Various *Mycosphaerella* spp. are present in Australia (APPD 2011)	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Order Pleosporales						
Corynespora cassiicola (Berk. & M.A. Curtis) C.T. Wei [Pleosporales: Corynesporasceae]	Yes (Shivas *et al.* 1996)	Yes Affects flowers, fruits, leaves, stem and roots (Thaung 2008; Farr and Rossman 2011)	Yes NSW, NT, Qld, Vic., WA (APPD 2011)	Assessment not required	Assessment not required	No
Class Eurotiomycetes						
Order Eurotiales						
Aspergillus niger Tiegh. [Eurotiales: Trichocomaceae] Fruit rot	Yes (IAQA 2011)	Yes Seed rot on mangosteen (Tamit 2002).	Yes All states and territories (APPD 2011)	Assessment not required	Assessment not required	No
Class Leotiomycetes						
Order Helotiales						
Gloeosporium garciniae Krood [Helotiales: Dermataceae] Leaf spot	Yes (Wibawa 2009)	No Associated with the leaves (Wibawa 2009).	No records found	Assessment not required	Assessment not required	No
Class Sordariomycetes						
Order Diaporthales						
Phomopsis sp. [Diaporthales: Diaporthaceae] Fruit rot	Yes (Shivas *et al.* 1996)	Yes A post-harvest disease that causes hardening of the pericarp and decay of the aril (Yaacob and Tindall 1995). Has been isolated from the internal tissue of fruit and stem of *G parviflora* (Sim *et al.* 2010).	Various *Phomopsis* spp. are present in Australia, including on mangosteen in Qld. and NT (APPD 2011).	Assessment not required	Assessment not required	No
Order Hypocreales						
Fusarium oxysporum Schltdl. [Hypocreales: Nectriaceae] Fusarium wilt	Yes (CABI 2011)	Yes Intercepted in Australia on fresh mangosteen fruit from Thailand.	Yes All states and territories (APPD 2011)	Assessment not required	Assessment not required	No

Pest	**Present in Indonesia**	**Potential to be on the pathway**	**Present within Australia**	**Potential for establishment and spread**	**Potential for economic consequences**	**Consider further in PRA**
Fusarium solani (Mart.) Sacc. Teleomorph: *Haematonectria haematococca* (Berk. & Broome) Samuels & Rossman [Hypocreales: Nectriaceae]	Yes (Farr and Rossman 2011)	Yes Affects bark, root and fruit (Farr and Rossman 2011).	Yes All states and territories (APPD 2011)	Assessment not required	Assessment not required	No
Order Phyllachorales						
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. Teleomorph: *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk [Phyllachorales: Phyllachoraceae] Anthracnose	Yes (Shivas *et al.* 1996)	Yes Occurs on stem, fruits and leaves (Osman and Milan 2006).	Yes All states and territories (APPD 2011)	Assessment not required	Assessment not required	No
Order Xylariales						
Pestalotia flagisetula Guba [Xylariales: Amphisphaeriaceae] Leaf spot	Yes (Rahayu and Sari 2011)	Yes Infects fruit and leaves. A weak pathogen or secondary invader that causes post-harvest rot in fruits that were bruised or damaged during harvest (Osman and Milan 2006).	Yes (Lim and Sangchote 2003)	Assessment not required	Assessment not required	No
Pestalotiopsis sp. [Xylariales: Amphisphaeriaceae]	Yes (Wibawa 2009)	No Causes leaf spot (Wibawa 2009).	Yes Various species are present in Australia (APPD 2011)	Assessment not required	Assessment not required	No
Order Unassigned						
Solicorynespora garciniae (Petch) G. Delgado & J. Mena [Incertae sedis: Incertae sedis]	Yes (Wibawa 2009)	No Affects the leaves (Wibawa 2009).	No records found	Assessment not required	Assessment not required	No

Pest	Present in Indonesia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Class Zygomycetes						
Order Mucorales						
Rhizopus stolonifer (Ehrenb.) Vuill. [Mucorales: Mucoraceae] Fruit rot	Yes (Astuti *et al.* 2000)	Yes Causes fruit rot (Farr and Rossman 2011). A post-harvest disease that causes hardening of the pericarp and decay of the aril (Yaacob and Tindall 1995).	Yes All states and territories (APPD 2011)	Assessment not required	Assessment not required	No
HETEROKONTOPHYTA: Ooymcetes						
Order Peronosporales						
Phytophthora palmivora (E.J. Butler) E.J. Butler [Peronosporales: Pythiaceae]	Yes (McMahon and Purwantara 2004)	No Causes crown and root rot of mangosteen (Tsao *et al.* 1994; Portales 2011). However, known to cause bud, crown, fruit, heart and root rots of fruits and crops (Ploetz 2004). No records of association with the mangosteen fruit.	Yes NSW, NT, Qld, Vic., (APPD 2011)	Assessment not required	Assessment not required	No
PLANTAE: Ulvophyceae						
Order Trentepohiales						
Cephaleuros virescens Künze [Trentepohliales: Trentepohliaceae] Algal leaf spot	Yes (Semangun 2000)	No Affects leaves by forming prominent spots of varying diameter that causes degeneration and discoloration of the host cells (Lim and Sangchote 2003).	Yes NSW, NT, Qld, Vic., WA (APPD 2011)	Assessment not required	Assessment not required	No

Appendix B Additional quarantine pest data

Quarantine pest	***Tetranychus* sp. Dufour ^{EP}**
Synonyms	None
Common name(s)	Spider mites
Main hosts	Most *Tetranychus* spp. are polyphagous while others are host specific (Migeon and Dorkeld 2010; Walter 2006). For a comprehensive list of *Tetranychus* spp. host plants, see Bolland *et al.* (1998).
Distribution	Presence in Australia: 11 species of the genus *Tetranychus* are present in Australia (Bolland *et al.* 1998). Presence in Indonesia: Genus present (Nasuton 2006) Presence elsewhere: The genus is present worldwide (APPD 2011)
Quarantine pest	***Curculio* sp.**
Synonyms	None
Common name(s)	
Main hosts	*Curculio* sp. infests *Garcinia mangostana* (Kalshoven 1981; Nasuton 2006).
Distribution	Presence in Australia: 3 species of the genus *Curculio* are present in Australia, none is recorded to feed on mangosteens (Hughes and Vogler 2004; APPD 2011). Presence in Indonesia: Genus present (Kalshoven 1981; Nasuton 2006) Presence elsewhere: The genus *Curculio* is distributed across Asia, Europe, Africa and North America (Hughes and Vogler 2004).
Quarantine pest	***Bactrocera carambolae* Drew & Hancock, 1994 ^{EP}**
Synonyms	None
Common name(s)	Carambola fruit fly
Main hosts	Recorded from 75 host plant species in 48 genera and 26 families. For a comprehensive list, see CABI (2011) and Allwood *et al.* (1999).
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Allwood *et al.* 1999). Presence elsewhere: South America, South and Southeast Asia (Cantrell *et al.* 2002; CABI 2011).
Quarantine pest	***Bactrocera papayae* Drew & Hancock, 1994 ^{EP}**
Synonyms	None
Common name(s)	Papaya fruit fly
Main hosts	Recorded from 193 host plant species in 114 genera and 50 families. For a comprehensive list, see Allwood *et al.* (1999).
Distribution	Presence in Australia: Detected in Queensland in 1995 and was declared eradiated in 1999 (Cantrell *et al.* 2002; CABI 2011). Presence in Indonesia: Yes (Drew and Hancock 1994; CABI 2011). Presence elsewhere: Southeast Asia and Papua New Guinea (CABI 2011).
Quarantine pest	***Drepanococcus chiton* (Green, 1909) ^{EP}**
Synonyms	*Ceroplastodes chiton* Green, 1909
Common name(s)	Soft scale
Main hosts	Sub-tropical fruit trees and shrubs across 15 families including: *Averrhoa carambola* (carombola), *Carica papaya* (papaya), *Citrus aurantifolia* (lime), *Solanum melongena* (eggplant), *Theobroma cacao* (cocoa) and *Camellia sinensis* (tea). For a comprehensive list, see Ben-Dov (2011b).
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Ben-Dov 2011b) Presence elsewhere: Papa New Guinea, Solomon Islands and Southeast Asia (CSIRO 2005).

Quarantine pest	***Diaspis boisduvalii* Signoret, 1869 WA**
Synonyms	*Diaspis boisduvalii* Signoret, 1869 *Aulacaspis boisduvalii* (Cockerell, 1893) *Aulacaspis cattleyae* Cockerell, 1899 *Diaspis cattleyae* (Cockerell, 1902) *Diaspis cymbidii* McIntire, 1889 *Aulacaspis cymbidii* (Fernald, 1903) *Diaspis trinacis* Colvée, 1881
Common name(s)	Boisduval scale, cocoa-nut snow scale, cocoa scale
Main hosts	Recorded from 44 genera across 15 families including: Orchidaceae (orchid), Arecaceae (palm) and Cactaceae (cactus). Horticulture hosts include, *Musa* spp. (banana), *Ananas comosus* (pineapple), *Coffea* (coffee) and *Cocos nucifera* (coconut). For a comprehensive list, see Miller *et al.* (2011).
Distribution	Presence in Australia: Tas., Qld, SA (CSIRO 2005), Vic. and NSW (APPD 2011). No records found for presence in WA. Presence in Indonesia: Yes (Tjoa 1960; Miller *et al.* 2011) Presence elsewhere: Near-cosmopolitan throughout North and South America, Africa, Europe and Asia (Miller *et al.* 2011)
Quarantine pest	***Ischnaspis longirostris* (Signoret, 1882) EP, WA**
Synonyms	*Mytilaspis longirostris* Signoret, 1882 *Ischnaspis longirostris* (Hempel, 1900) *Ischnaspis filiformis* Douglas, 1887 *Mytilaspis ritzemaebosi* Leonardi, 1901 *Lepidosaphes ritsemabosi* (Fernald, 1903)
Common name(s)	Black thread scale, black line scale
Main hosts	Recorded from 70 genera across 35 families including: *Citrus*, *Cocos nucifera* (coconut), *Coffea* (coffee), *Mangifera indica* (mango), *Persea americana* (avocado) and *Musa* spp. (banana). For a comprehensive list, see Miller *et al.* (2011).
Distribution	Presence in Australia: NT and Qld (CSIRO 2005; APPD 2011). No records found for presence in WA. Presence in Indonesia: Yes (Miller *et al.* 2011) Presence elsewhere: Near-cosmopolitan throughout North and South America, Africa, Europe and Asia (Miller *et al.* 2011).
Quarantine pest	***Pseudaonidia trilobitiformis* (Green, 1896) EP, WA**
Synonyms	*Aspidiotus trilobitiformis* Green, 1896 *Aspiditus darutyi* Charmoy, 1898 *Pseudaonidia trilobitiformis darutyi* (Fernald, 1903) *Pseudaonidia darutyi* (Marlatt, 1908)
Common name(s)	Trilobite scale, cashew scale, gingging scale, trilobe scale
Main hosts	Recorded from 80 genera across 42 families including: *Anacardium occidentale* (cashew nut), *Citrus, Coffea* (coffee), *Persea americana* (avocado), *Mangifera indica* (mango) and *Cacao* (cacao bean). For a comprehensive list, see Ben-Dov (2011c).
Distribution	Presence in Australia: NT and Qld (CSIRO 2005; APPD 2011). No records found for presence in WA. Presence in Indonesia: Yes (Ben-Dov 2011c) Presence elsewhere: Near-cosmopolitan throughout North and South America, Africa and Asia (Williams 2004).
Quarantine pest	***Dysmicoccus lepelleyi* (Betrem, 1937)**
Synonyms	*Pseudococcus lepelleyi* Betrem, 1937 *Criniticoccus palmae* Lit, 1992
Common name(s)	Annona mealybug

Main hosts	Recorded from more than 30 genera across17 families including: *Garcinia mangostana* (mangosteen), *Mangifera indica* (mango), *Ficus variegata* (variegated fig), *Psidium guajava* (guava), *Coffea* (coffee), *Citrus*, *Litchi chinensis* (lychee), *Nephelium lappaceum* (rambutan), *Theobroma cacao* (cacao), and *Musa* (banana). For a comprehensive list, see Ben-Dov (2011d).
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Ben-Dov 2011d). Presence elsewhere: Southeast Asia (Williams 2004)
Quarantine pest	***Exallomochlus hispidus* (Morrison, 1921)**
Synonyms	*Pseudococcus hispidus* Morrison, 1921 *Pseudococcus jacobsoni* Green, 1930 *Erium hispidum* (Lindinger, 1935) *Cataenococcus hispidus* (Williams, 1970) *Paraputo hispidus* (Tang, 1992)
Common name(s)	Cocoa mealybug
Main hosts	Recorded from more than 50 hosts form 28 families including: *Garcinia mangostana* (mangosteen), *Psidium guajava* (guava), *Annona muricata* (soursop), *Hibiscus*, *Citrus maxima* (pummelo), *Durio oblongus* (durian) and *Polyalthia cauliflora* (coconut palm). For a comprehensive list, see Williams (2004).
Distribution	Presence in Australia: No records found. Presence in Indonesia: Yes (Ben-Dov 2011d). Presence elsewhere: Southeast Asia (Williams 2004).
Quarantine pest	***Hordeolicoccus heterotrichus* Williams, 2004**
Synonyms	None
Common name(s)	Citrus mealybug
Main hosts	Recorded from a number of hosts from the following families: Burseaceae, Clusiaceae, Crypteroniaceae, Fabaceae, Myristicaceae, Myrtaceae, Rubiaceae and Sapindaceae (Williams 2004).
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Ben-Dov 2011d) Presence elsewhere: Southeast Asia (Williams 2004).
Quarantine pest	***Paracoccus interceptus* Lit, 1997**
Synonyms	*Allococcus morrisoni* Ezzat & McConnell, 1956 *Planococcus morrisoni* (Cox & Ben-Dov, 1986) *Paracoccus morrisoni* Lit, 1997
Common name(s)	Intercepted mealybug
Main hosts	Recorded from more than 24 host plant species across 18 families including: *Garcinia mangostana* (mangosteens), *Mangifera indica* (mango), *Annona cherimola* (custard apple), *Ficus* (fig), *Psidium guajava* (guava), *Citrus*, *Litchi chinensis* (lychee), and *Nephelium lappaceum* (rambutan). For a comprehensive list, see Williams (2004).
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Ben-Dov 2011d) Presence elsewhere: Southeast Asia (Williams 2004).
Quarantine pest	***Paraputo odontomachi* (Takahashi, 1951)**
Synonyms	*Formicoccus odontomachi* Takahashi, 1951
Common name(s)	None
Main hosts	*Garcinia mangostana* (mangosteen) *Crypteronia griffithii*, *Crypteronia macrophylla*, *Elaeocarpus petiolatus*, *Bischofia*, and *Neonauclea* (labula) (Williams 2004)
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Ben-Dov 2011d). Presence elsewhere: Southeast Asia (Williams 2004).

Quarantine pest	***Planococcus lilacinus* (Cockerell, 1905) $^{\text{EP}}$**
Synonyms	*Pseudococcus tayabanus* Cockerell, 1905 *Dactylopius crotonis* Green, 1906 *Dactylopius coffeae* Newstead, 1908 *Pseudococcus coffeae* (Sanders, 1909) *Dactylopius crotonis* Green, 1911 *Pseudococcus crotonis* (Sasscer, 1912) *Pseudococcus deceptor* Betrem, 1937 *Tylococcus mauritiensis* Mamet, 1939 *Planococcus crotonis* (Ferris, 1950) *Planococcus tayabanus* (Ferris, 1950)
Common name(s)	Coffee mealybug
Main hosts	Recorded from a wide host range across 35 families including: *Theobroma cacao* (cocoa), *Psidium guajava* (guava), *Coffea* spp. (coffee), and *Mangifera indica* (mango). For a comprehensive list, see Ben-Dov (2011d).
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (CABI 2011; Ben-Dov 2011d). Presence elsewhere: Near-cosmopolitan including Central America, East Africa, South, South-east and East Asia (CABI 2011).
Quarantine pest	***Planococcus minor* (Maskell, 1897) $^{\text{EP, WA}}$**
Synonyms	*Dactylopius calceolariae minor* Maskell, 1897 *Pseudococcus calceolariae minor* (Fernald, 1903) *Planococcus pacificus* Cox, 1981 *Planococcus psidii* Cox, 1989
Common name(s)	Pacific mealybug
Main hosts	Recorded from a wide host range across 70 families including: *Garcinia mangostana* (mangosteen), *Citrus deliciosa* (mediterranean mandarin), *Citrus reticulata* (mandarin), *Acacia* sp., *Coffea* (coffee), *Colocasia esculenta* (taro), *Mangifera indica* (mango), *Psidium guajava* (guava), *Eucalyptus deglupta* (rainbow eucalyptus), and *Zea mays* (maize). For a comprehensive list, see, (Williams (2004) and CABI (2011).
Distribution	Presence in Australia: ACT, NT, Qld and SA (APPD 2011). No records found for presence in WA. Presence in Indonesia: Yes (Ben-Dov 2011d). Presence elsewhere: Central and South America, East Africa, Oceania, South and Southeast Asia (Williams 2004; CABI 2011).
Quarantine pest	***Pseudococcus aurantiacus* Williams, 2004**
Synonyms	None
Common name(s)	Orange-coloured mealybug
Main hosts	*Garcinia mangostana* (mangosteen), *Schefflera* (umbrella tree), *Callophyllum* (Santa Maria), *Crypteronia griffithii*, *Millettia nieuwenhuisii*, *Ryparosa fasciculata*, *Strychnos vanprukii*, *Lansium domesticum* (langsat), *Averrhoa carambola* (star fruit), *Neonauclea* (labula), and *Nephelium lappaceum* (rambutan) (Ben-Dov 2011d).
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Ben-Dov 2011d) Presence elsewhere: Southeast Asia (Williams 2004).
Quarantine pest	***Pseudococcus baliteus* Lit, 1994**
Synonyms	None
Common name(s)	Aerial root mealybug
Main hosts	*Garcinia mangostana* (mangosteen), *Durio zibethinus* (durian), *Poikilospermum suaveolans*, *Dracaena*, *Lansium domesticum* (lansat), *Artocarpus odoratissimus* (breadfruit), *Ficus elastica* (rubber fig), *Osbornia octodonta* (myrtle mangrove), *Psidium guajava* (guava), *Syzygium* (lilly pilly), *Citrus sinensis* (sweet orange), *Dimocarpus longan* (longan), *Litchi chinensis* (lychee), and *Nephelium lappaceum* (rambutan) (Williams 2004).

Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Ben-Dov 2011d). Presence elsewhere: East and Southeast Asia (Williams 2004)
Quarantine pest	***Pseudococcus cryptus* Hempel,1918** ^{EP}
Synonyms	*Pseudococcus citriculus* Green, 1922 *Pseudococcus spathoglottidis* Lit, 1992 *Pseudococcus mandarinus* Das & Ghose, 1996
Common name(s)	Cryptic mealybug, citriculus mealybug, ground orchid mealybug
Main hosts	Recorded from a wide host range across 45 families including: *Citrus*, *Garcinia mangostana* (mangosteen), *Litchi chinensis* (lychee), *Coffea Arabica* (coffee), *Ananas sativa* (pineapple), *Musa* (banana), and *Vitis vinifera* (grape vine). For a comprehensive list, see Ben-Dov (2011).
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Ben-Dov 2011d) Presence elsewhere: South and Central America, East Africa, Mid-eastern Mediterranean, South, South-east and East Asia, Oceania except Australia and New Zealand (Williams 2004).
Quarantine pest	***Rastrococcus spinosus* (Robinson, 1918)** ^{EP}
Synonyms	*Phenacoccus spinosus* Robinson, 1918 *Puto spinosus* (Morrison, 1920) *Ceroputo spinosus* (van der Goot, 1928)
Common name(s)	Philippine mango mealybug
Main hosts	Recorded from more than 30 host plant species across 18 families including: *Garcinia mangostana* (mangosteen), *Anacardium occidentale* (cashew), *Mangifera indica* (mango), *Cocos nucifera* (coconut palm), *Artocarpus altilis* (breadfruit), *Artocarpus heterophyllus* (jackfruit), *Ficus ampelas* (fig), *Psidium guajava* (guava), *Coffea* (coffee) *Citrus* (citrus) and *Theobroma cacao* (cacao tree). For a comprehensive list, see Ben-Dov (2011).
Distribution	Presence in Australia: No records found Presence in Indonesia: Yes (Ben-Dov 2011d) Presence elsewhere: South and Southeast Asia (Ben-Dov 2011d) (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010).
Quarantine pest	***Camponotus* sp.**
Synonyms	None
Common name(s)	Carpenter ant
Main hosts	Ants are known “hitch-hikers” that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Camponotus* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present worldwide (Guénard *et al.* 2010)
Quarantine pest	***Cardiocondyla* sp.**
Synonyms	None
Common name(s)	
Main hosts	Ants are known “hitch-hikers” that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Cardiocondyla* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present worldwide, although absent from North America and exotic to Central and South America (Guénard *et al.* 2010).
Quarantine pest	***Crematogaster* sp.**
Synonyms	None
Common name(s)	Semut kripik

Main hosts	Ants are known "hitch-hikers" that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Crematogaster* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011) Presence in Indonesia: Genus present (Kalshoven 1981; Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present worldwide (Guénard *et al.* 2010).
Quarantine pest	***Dolichoderus* sp.** ^{EP}
Synonyms	None
Common name(s)	
Main hosts	Ants are known "hitch-hikers" that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Dolichoderus* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present worldwide, although absent from Central and Southern Africa (Guénard *et al.* 2010).
Quarantine pest	***Iridomyrmex* sp.**
Synonyms	None
Common name(s)	
Main hosts	Ants are known "hitch-hikers" that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Iridomyrmex* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Guénard *et al.* 2010) Presence elsewhere: The genus is present in South Asia, Southeast Asia and China (Guénard *et al.* 2010).
Quarantine pest	***Monomorium* sp.**
Synonyms	None
Common name(s)	
Main hosts	Ants are known "hitch-hikers" that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Monomorium* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present worldwide (Guénard *et al.* 2010).
Quarantine pest	***Paratrechina* sp.**
Synonyms	None
Common name(s)	
Main hosts	Ants are known "hitch-hikers" that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Paratrechina* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present worldwide (Guénard *et al.* 2010).
Quarantine pest	***Pheidole* sp.**
Synonyms	None
Common name(s)	
Main hosts	Ants are known "hitch-hikers" that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.

Distribution	Presence in Australia: Species of the genus *Pheidole* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present worldwide (Guénard *et al.* 2010).
Quarantine pest	***Plagiolepis* sp.**
Synonyms	None
Common name(s)	
Main hosts	Ants are known “hitch-hikers” that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Plagiolepis* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present worldwide, although absent from northern Europe, North and South America (Guénard *et al.* 2010).
Quarantine pest	***Polyrhachis* sp.**
Synonyms	None
Common name(s)	
Main hosts	Ants are known “hitch-hikers” that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Polyrhachis* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010). Presence elsewhere: The genus is present in Africa, Middle East, South and Central Asia, Southeast Asia, China, and New Guinea (Guénard *et al.* 2010).
Quarantine pest	***Tapinoma* sp.**
Synonyms	None
Common name(s)	
Main hosts	Ants are known “hitch-hikers” that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Tapinoma* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011) Presence in Indonesia: Genus present (Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present worldwide (Guénard *et al.* 2010).
Quarantine pest	***Technomyrmex* sp.** ^{EP}
Synonyms	None
Common name(s)	
Main hosts	Ants are known “hitch-hikers” that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Species of the genus *Technomyrmex* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010) Presence elsewhere: The genus is present in central and northern South America, Africa, Middle East, south and central Asia, Southeast Asia, China, and New Guinea (Guénard *et al.* 2010).
Quarantine pest	***Tetramorium* sp.**
Synonyms	None
Common name(s)	
Main hosts	Ants are known “hitch-hikers” that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.

Distribution	Presence in Australia: Species of the genus *Tetramorium* are present in Australia. However, some individual species may not be present in Australia (CSIRO 2011). Presence in Indonesia: Genus present (Ito *et al.* 2001; Rizali *et al.* 2008; Guénard *et al.* 2010). Presence elsewhere: The genus is present in worldwide, although absent from western Canada and Alaska (Guénard *et al.* 2010).
Quarantine pest	***Wasmannia auropunctata* (Roger, 1863) ^{EP}**
Synonyms	Hercynia panamana Enzmann, 1947 Ochetomyrmex auropunctata (Forel, 1886) Ochetomyrmex auropunctatum (Forel, 1886) Ochetomyrmex auropunctatus (Roger, 1863) Tetramorium auropunctatum Roger, 1863 Wasmannia glabra Santschi, 1931 Xiphomyrmex atomum Santschi, 1914
Common name(s)	Little fire ant; Electric ant
Main hosts	Ants are known “hitch-hikers” that tend several groups of sucking insects that are found under the calyces of mangosteens, such as Coccidae and Pseudococcidae, for their honeydew.
Distribution	Presence in Australia: Yes. Queensland: a declared pest and under official control (Windle 2011). Presence in Indonesia: Yes (Wetterer and Porter 2003; Guénard *et al.* 2010). Presence elsewhere: Native to South and Central America and introduced to several Pacific island groups including Fiji, French Polynesia, Galapagos Islands, Hawaii, New Caledonia, Solomon Islands, Tuvalu, Vanuatu, Wallis and Futuna (Wetterer and Porter 2003), mainland USA (Florida and California), the Caribbean, Gabon and Cameroon (Wetterer *et al.* 1999), Canada, Ecuador, Israel, and Papua New Guinea (GISD 2009).

Appendix C Scientific issues raised in stakeholder comments

A summary of major stakeholder issues and how they were considered in the final report is given below.

Issue 1: One stakeholder wrote that the pest risk assessment (PRA) process for fruit flies was conducted using unpublished reports and ignored published information and expert comments.

DAFF Biosecurity has considered all available published and unpublished references regarding the host status of mangosteen for fruit flies. This information is included in the PRA for the fruit flies *Bactrocera papayae* and *B.carambolae*. In addition, national and international fruit fly experts were consulted on the host status of mangosteens for fruit flies, and their comments were carefully considered. Based on the available evidence, DAFF Biosecurity concluded that mangosteen fruit are conditional non-hosts when undamaged and at specific maturity levels.

Issue 2: One stakeholder asked for a re-examination of the risk assessment for fruit flies and mealybugs.

All relevant references and expert comments were carefully considered again, and in the absence of any new information, changes to the risk assessment for fruit flies and mealybugs were not justified. The risk management measures recommended in this report are considered appropriate to reduce the risk for all identified quarantine pests to achieve Australia’s appropriate level of protection (ALOP).

Appendix D Biosecurity framework

Australia's biosecurity policies

The objective of Australia's biosecurity policies and risk management measures is the prevention or control of the entry, establishment or spread of pests and diseases that could cause significant harm to people, animals, plants and other aspects of the environment.

Australia has diverse native flora and fauna and a large agricultural sector, and is relatively free from the more significant pests and diseases present in other countries. Therefore, successive Australian Governments have maintained a conservative, but not a zero-risk, approach to the management of biosecurity risks. This approach is consistent with the World Trade Organization's (WTO's) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).

The SPS Agreement defines the concept of an 'appropriate level of protection' (ALOP) as the level of protection deemed appropriate by a WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory. Among a number of obligations, a WTO Member should take into account the objective of minimising negative trade effects in setting its ALOP.

Like many other countries, Australia expresses its ALOP in qualitative terms. Australia's ALOP, which reflects community expectations through Australian Government policy, is currently expressed as providing a high level of sanitary and phytosanitary protection, aimed at reducing risk to a very low level, but not to zero.

Consistent with the SPS Agreement, in conducting risk analyses Australia takes into account as relevant economic factors:

- the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease in the territory of Australia
- the costs of control or eradication of a pest or disease
- and the relative cost-effectiveness of alternative approaches to limiting risks.

Roles and responsibilities within Australia's quarantine system

Australia protects its human[6], animal and plant life or health through a comprehensive quarantine system that covers the quarantine continuum, from pre-border to border and post-border activities.

Pre-border, Australia participates in international standard-setting bodies, undertakes risk analyses, develops offshore quarantine arrangements where appropriate, and engages with our neighbours to counter the spread of exotic pests and diseases.

At the border, Australia screens vessels (including aircraft), people and goods entering the country to detect potential threats to Australian human, animal and plant health.

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[6] The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine.

The Australian Government also undertakes targeted measures at the immediate post-border level within Australia. This includes national co-ordination of emergency responses to pest and disease incursions. The movement of goods of quarantine concern within Australia's border is the responsibility of relevant state and territory authorities, which undertake inter- and intra-state quarantine operations that reflect regional differences in pest and disease status, as a part of their wider plant and animal health responsibilities.

Roles and responsibilities within the Department

The Australian Government Department of Agriculture, Fisheries and Forestry is responsible for the Australian Government's animal and plant biosecurity policy development and the establishment of risk management measures. The Secretary of the Department is appointed as the Director of Animal and Plant Quarantine under the *Quarantine Act 1908* (the Act).

The Department takes the lead in biosecurity and quarantine policy development and the establishment and implementation of risk management measures across the biosecurity continuum, and:

- **Pre-border** conducts risk analyses, including IRAs, and develops recommendations for biosecurity policy as well as providing quarantine policy advice to the Director of Animal and Plant Quarantine
- **At the border** develops operational procedures, makes a range of quarantine decisions under the Act (including import permit decisions under delegation from the Director of Animal and Plant Quarantine) and delivers quarantine services
- **Post-border** coordinates pest and disease preparedness, emergency responses and liaison on inter- and intra-state quarantine arrangements for the Australian Government, in conjunction with Australia's state and territory governments.

Roles and responsibilities of other government agencies

State and territory governments play a vital role in the quarantine continuum. The Department works in partnership with state and territory governments to address regional differences in pest and disease status and risk within Australia, and develops appropriate sanitary and phytosanitary measures to account for those differences. Australia's partnership approach to quarantine is supported by a formal Memorandum of Understanding that provides for consultation between the Australian Government and the state and territory governments.

Depending on the nature of the good being imported or proposed for importation, DAFF Biosecurity may consult other Australian Government authorities or agencies in developing its recommendations and providing advice.

As well as a Director of Animal and Plant Quarantine, the Act provides for a Director of Human Quarantine. The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine and Australia's Chief Medical Officer within that Department holds the position of Director of Human Quarantine. DAFF Biosecurity may, where appropriate, consult with that Department on relevant matters that may have implications for human health.

The Act also requires the Director of Animal and Plant Quarantine, before making certain decisions, to request advice from the Environment Minister and to take the advice into account when making those decisions. The Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) is responsible under the Environment Protection and Biodiversity Conservation Act 1999 for assessing the environmental impact associated with proposals to import live species. Anyone proposing to import such material should contact DSEWPaC directly for further information.

When undertaking risk analyses, DAFF Biosecurity consults with DSEWPaC about environmental issues and may use or refer to DSEWPaC's assessment.

Australian quarantine legislation

The Australian quarantine system is supported by Commonwealth, state and territory quarantine laws. Under the Australian Constitution, the Commonwealth Government does not have exclusive power to make laws in relation to quarantine, and as a result, Commonwealth and state quarantine laws can co-exist.

Commonwealth quarantine laws are contained in the *Quarantine Act 1908* and subordinate legislation including the Quarantine Regulations 2000, the Quarantine Proclamation 1998, the Quarantine (Cocos Islands) Proclamation 2004 and the Quarantine (Christmas Island) Proclamation 2004.

The quarantine proclamations identify goods, which cannot be imported, into Australia, the Cocos Islands and or Christmas Island unless the Director of Animal and Plant Quarantine or delegate grants an import permit or unless they comply with other conditions specified in the proclamations. Section 70 of the Quarantine Proclamation 1998, section 34 of the Quarantine (Cocos Islands) Proclamation 2004 and section 34 of the Quarantine (Christmas Island) Proclamation 2004 specify the things a Director of Animal and Plant Quarantine must take into account when deciding whether to grant a permit.

In particular, a Director of Animal and Plant Quarantine (or delegate):

- must consider the level of quarantine risk if the permit were granted, and
- must consider whether, if the permit were granted, the imposition of conditions would be necessary to limit the level of quarantine risk to one that is acceptably low, and
- for a permit to import a seed of a plant that was produced by genetic manipulation – must take into account any risk assessment prepared, and any decision made, in relation to the seed under the Gene Technology Act, and
- may take into account anything else that he or she knows is relevant.

The level of quarantine risk is defined in section 5D of the *Quarantine Act 1908*. The definition is as follows:

> reference in this Act to a *level of quarantine risk* is a reference to:
>
> (a) the probability of:
>
> (i) a disease or pest being introduced, established or spread in Australia, the Cocos Islands or Christmas Island; and

(ii) the disease or pest causing harm to human beings, animals, plants, other aspects of the environment, or economic activities; and

(b) the probable extent of the harm.

The Quarantine Regulations 2000 were amended in 2007 to regulate keys steps of the import risk analysis process. The Regulations:

- define both a standard and an expanded IRA;
- identify certain steps, which must be included in each type of IRA;
- specify time limits for certain steps and overall timeframes for the completion of IRAs (up to 24 months for a standard IRA and up to 30 months for an expanded IRA);
- specify publication requirements;
- make provision for termination of an IRA; and
- allow for a partially completed risk analysis to be completed as an IRA under the Regulations.

The Regulations are available at http://www.comlaw.gov.au

International agreements and standards

The process set out in the *Import Risk Analysis Handbook 2011* is consistent with Australia's international obligations under the SPS Agreement. It also takes into account relevant international standards on risk assessment developed under the International Plant Protection Convention (IPPC) and by the World Organisation for Animal Health (OIE).

Australia bases its national risk management measures on international standards where they exist and when they achieve Australia's ALOP. Otherwise, Australia exercises its right under the SPS Agreement to apply science-based sanitary and phytosanitary measures that are not more trade restrictive than required to achieve Australia's ALOP.

Notification obligations

Under the transparency provisions of the SPS Agreement, WTO Members are required, among other things, to notify other members of proposed sanitary or phytosanitary regulations, or changes to existing regulations, that are not substantially the same as the content of an international standard and that may have a significant effect on trade of other WTO Members.

Risk analysis

Within Australia's quarantine framework, the Australian Government uses risk analyses to assist it in considering the level of quarantine risk that may be associated with the importation or proposed importation of animals, plants or other goods.

In conducting a risk analysis, DAFF Biosecurity:

- identifies the pests and diseases of quarantine concern that may be carried by the good

- assesses the likelihood that an identified pest or disease or pest would enter, establish or spread
- assesses the probable extent of the harm that would result.

If the assessed level of quarantine risk exceeds Australia’s ALOP, DAFF Biosecurity will consider whether there are any risk management measures that will reduce quarantine risk to achieve the ALOP. If there are no risk management measures that reduce the risk to that level, trade will not be allowed.

Risk analyses may be carried out by DAFF Biosecurity’s specialists, but may also involve relevant experts from state and territory agencies, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), universities and industry to access the technical expertise needed for a particular analysis.

Risk analyses are conducted across a spectrum of scientific complexity and available scientific information. An IRA is a type of risk analysis with key steps regulated under the Quarantine Regulations 2000. DAFF Biosecurity’s assessment of risk may also take the form of a non-regulated analysis of existing policy or technical advice. Further information on the types of risk analysis is provided in the *Import Risk Analysis Handbook 2011*.

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 2009).
Apomixis	Asexual reproduction of plants
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).
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2009).
Area of low pest prevalence	An area, whether all of a country, part of a country, or all parts of several countries, as identified by the competent authorities, in which a specific pest occurs at low levels and which is subject to effective surveillance, control or eradication measures (FAO 2009).
Aril	A fleshy, usually brightly coloured cover of a seed
Arthropod	The largest phylum of animals, including the insects, arachnids and crustaceans
Asexual reproduction	The development of new individual from a single cell or group of cells in the absence of meiosis
Biosecurity Australia	The unit, within the Department of Agriculture, Fisheries and Forestry, responsible for recommendations for the development of Australia's biosecurity policy.
Calyx	A collective term referring to all of the sepals in a flower
Certificate	An official document which attests to the phytosanitary status of any consignment affected by phytosanitary regulations (FAO 2009).
Consignment	A quantity of plants, plant products and/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 or lots) (FAO 2009).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2009).
Crawler	Intermediate mobile nymph stage of certain Arthropods
Diapause	Period of suspended development/growth occurring in some insects, in which metabolism is decreased
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 2009).
Endemic	Belonging to, native to, or prevalent in a particular geography, area or environment
Endocarp	The hard inner layer of the pericarp, such as pit or stone of a cherry, peach or olive
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 2009).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2009).
Exocarp	The outer most layer of the fruit wall
Fecundity	The fertility of an organism
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2009).
Fumigation	A method of pest control that completely fills an area with gaseous pesticides to suffocate or poison the pests within
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
Host	An organism that harbours a parasite, mutual partner, or commensal partner, typically providing nourishment and shelter

Term or abbreviation	Definition
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2009).
Hybridisation	The production of offspring of genetically different parents
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2009).
Import risk analysis	An administrative process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication
Infection	The internal 'endophytic' colonisation of a plant, or plant organ, and is 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 2009).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present and/or to determine compliance with phytosanitary regulations (FAO 2009).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used (FAO 2009).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2009).
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 IPCC (FAO 2009).
Introduction	The entry of a pest resulting in its establishment (FAO 2009).
Larva	A juvenile form of animal with indirect development, undergoing metamorphosis (for example, insects or amphibians)
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment (FAO 2009). Within this report a 'lot' refers to a quantity of fruit of a single variety, harvested from a single production site during a single pick and packed at one time
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
Mesocarp	The middle, usally fleshy layer of a fruit wall
Mortality	The total number of organisms killed by a particular disease
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2009).
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 2009).
Orchard	A contiguous area of mangosteen trees operated as a single entity. Within this report a single orchard is covered under one registration and is issued a unique indentifying number
Parthenognesis	Production of an embryo from unfertilised egg
Pathogen	A biological agent that can cause disease to its host
Pathway	Any means that allows the entry or spread of a pest (FAO 2009).
Pericarp	The tissue that arises from the ripen ovary wall of the fruit
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2009).

Term or abbreviation	Definition
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 2009).
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 2009).
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 2009).
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 2009).
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 2009).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences (FAO 2009).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2009).
Phloem	In vascular plants, the tissue that carries organic nutrients to all parts of the plant where needed
Phytosanitary certificate	Certificate patterned after the model certificates of the IPPC (FAO 2009).
Phytosanitary measure	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 2009).
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 2009).
Polyphagous	Feeding on a relatively large number of hosts from different plant family and/or genera
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2009).
Production site	In this report, a production site is a continuous planting of mangosteen trees treated as a single unit for pest management purposes. If an orchard is 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
Pupa	An inactive life stage that only occurs in insects that undergo complete metamorphosis, for example butterflies and moths (Lepidoptera), beetles (Coleoptera) and bees, wasps and ants (Hymenoptera)
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 2009).
Regulated article	Any plant, plant product, storage place, packing, 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 (WTO 1995)
Restricted risk	Risk estimate with phytosanitary measure(s) applied
Saprophyte	An organism deriving its nourishment from dead organic matter
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO 2009).
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
Stamen	The male reproduction organ of a flower

Term or abbreviation	**Definition**
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 stalks
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk mitigation measures
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

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