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Biosecurity Australia

Final Import Risk Analysis Report for Fresh Mango Fruit from India

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Cover image: Mango fruit (Kesar variety)

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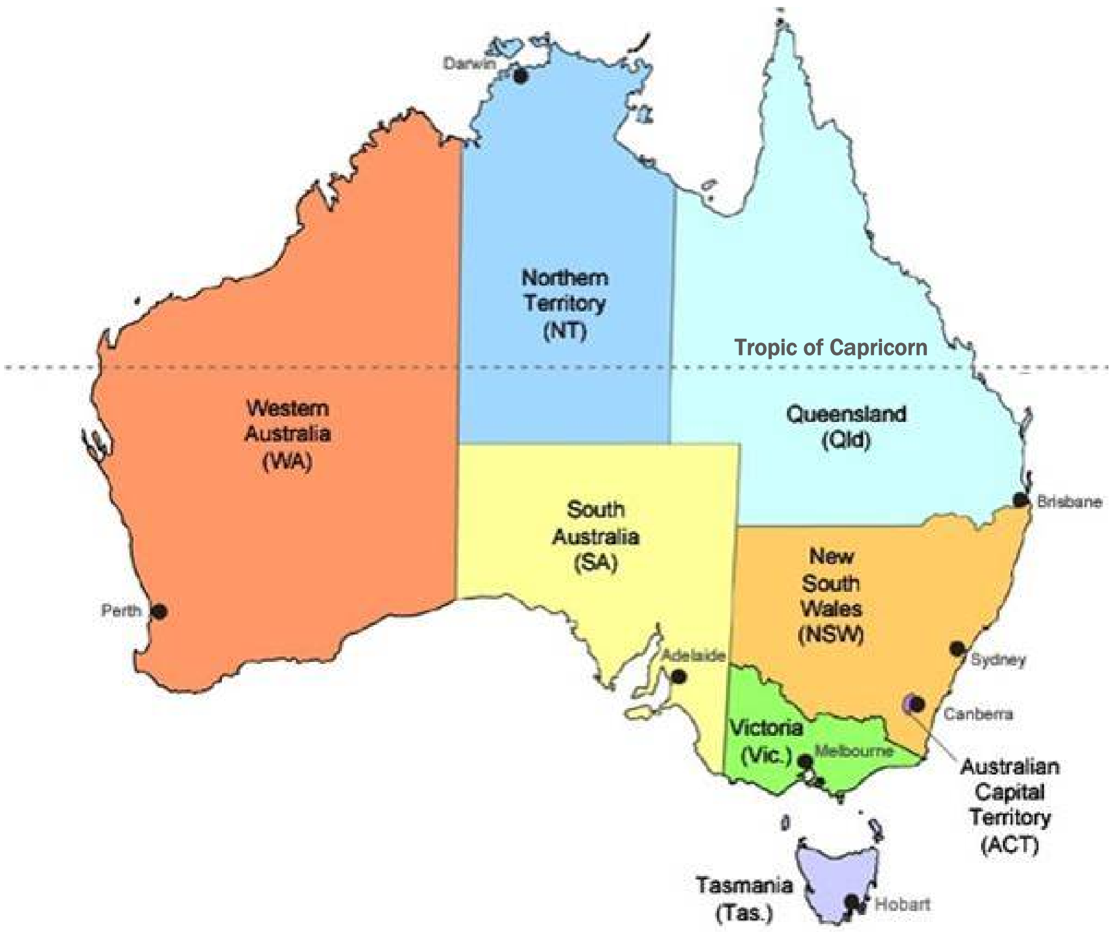
Map of Australia



Acronyms and abbreviations

Term or abbreviation	Definition
ALOP	Appropriate level of protection. 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)
APEDA	Agricultural and Processed Food Products Export Development Authority, India
AQIS	Australian Quarantine and Inspection Service
BA	Biosecurity Australia
DAC	Department of Agriculture and Cooperation, India
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
DAWA	Department of Agriculture, Western Australia
FAO	Food and Agriculture Organization of the United Nations
FSANZ	Food Standards Australia and New Zealand
ICON	AQIS Import Conditions database
IPC	International phytosanitary certificate
IPPC	International Plant Protection Convention. As deposited with FAO in Rome in 1951 and subsequently amended (FAO 2007b)
IRA	Import Risk Analysis. The assessment of the level of risk associated with the importation, or proposed importation, of animal, plants or other goods and, where necessary, the identification of risk management options to limit the level of quarantine risk to one that is acceptably low (*Quarantine Act 1908*)
ISPM	International Standard for Phytosanitary Measures. 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 2007b)
NPPO	National Plant Protection Organization. Official service established by a government to discharge the functions specified by the IPPC (FAO 2007b)
NSW	New South Wales
NT	Northern Territory
PFA	Pest Free Area. 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 2007b)
PRA	Pest Risk Analysis. 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 2007b)
Qld	Queensland
SA	South Australia
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995)
Tas.	Tasmania
Vic.	Victoria
WA	Western Australia
WTO	World Trade Organization

Summary

This import risk analysis has assessed a proposal from India for market access to Australia for fresh mango fruit.

Australia has existing quarantine policy that allows the importation of mangoes from Haiti, Mexico, the Philippines (Guimaras Island) and Taiwan, subject to specific quarantine conditions.

This report recommends that the importation of fresh mango fruit (*Mangifera indica* L.) to Australia from India be permitted, subject to specific quarantine conditions.

The report takes account of stakeholders' comments and submissions on the 2004 draft report.

In October 2006, India requested that Australia consider irradiation as a quarantine measure for fresh mango fruit. In view of this, quarantine measures that were proposed in the 2004 draft report, including vapour heat treatment, hot water treatment and pest free areas, have not been considered further.

The report identifies fruit flies, mealybugs, red-banded mango caterpillar and mango weevils as 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 existing commercial production practice of a post-harvest fungicidal dip, as advised by India to support its market access application, is an underlying requirement for export to Australia.

The recommended quarantine measures are pre-export irradiation treatment at 400 Gray, supported by an operational system to maintain and verify quarantine status. The Australian Quarantine and Inspection Service will be present to pre-clear and verify irradiation treatment of mangoes prior to export.

Three pests, mango seed weevil and two mealybug species, which are present in eastern Australia, have been identified as quarantine pests for Western Australia only. The recommended quarantine measures take account of these regional differences for Western Australia.

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 consider formally the risks that could be associated with proposals to import new products into Australia. If the risks are found not to achieve 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 Biosecurity Australia using teams of technical and scientific experts in relevant fields, and involving consultation with stakeholders at various stages during the process. The recommendations from Biosecurity Australia are provided to the Director of Animal and Plant Quarantine (the Secretary of the Australian Department of Agriculture, Fisheries and Forestry), who is responsible for determining whether or not an importation can be permitted under the *Quarantine Act 1908*, and if so, under what conditions. The Australian Quarantine and Inspection Service (AQIS) are responsible for implementing the import protocol, including any risk management measures.

More information about Australia’s biosecurity framework is provided in Appendix C of this report and in the *Import Risk Analysis Handbook 2007* located on the Biosecurity Australia website www.biosecurityaustralia.gov.au.

1.2. This import risk analysis

1.2.1. Background

Prior to 1996, India exported fresh mango fruit to Australia with a mandatory on-arrival fumigation treatment using ethylene dibromide (EDB). Imports of fresh mango fruit from India were suspended in 1996 as a result of the global phase-out of the use of EDB on the basis of concerns for worker health and safety. Following the EDB phase-out, India was requested to propose equivalent measures and provide appropriate efficacy data.

In 2000, the Agricultural and Processed Food Products Export Development Authority (APEDA) and the Ministry of Agriculture of the Republic of India provided an import

[1] A pest is any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2007b)

proposal for fresh mango fruit (*Mangifera indica* L.) to Australia. A comprehensive pest list was included with this request.
In 2002 and 2003, India provided supporting information on production practices and additional pests associated with fresh mango fruit in India. India's existing commercial production practices were observed by officers from both Biosecurity Australia and AQIS in April 2003.

On 12 September 2003, Biosecurity Australia advised stakeholders in Biosecurity Australia Policy Memorandum 2003/27 that the pest risk analysis on fresh mango fruit from India would be progressed as a review of existing policy. A draft policy report was issued in July 2004 for stakeholder comment.

The draft report proposed vapour heat treatment or hot water treatment for fruit flies and the use of designated 'pest free areas' for mango weevils, as requested by India at that time. Visual inspection and remedial action were also proposed for the red-banded caterpillar, mealybugs and scale insects.

1.2.2. Scope

This Report assesses the biosecurity risks associated with fresh mango fruit from India and recommends quarantine measures for identified risks. Details of the production processes for this fruit in India are set out in section 3.

In October 2006, India requested that Australia consider irradiation as a quarantine measure for fresh mango fruit. In view of this circumstance, quarantine measures proposed in the 2004 draft report, including vapour heat treatment, hot water treatment and pest free areas, have not been further considered for fresh mango fruit from India.

Due to India's request to consider irradiation, differences between the draft report and this Report are referred to in Section 5 and annotated in the Report.

1.2.3. Existing policy

Australia has existing policy for fresh mango fruit from a number of countries including Haiti, Mexico, the Philippines (Guimaras Island) and Taiwan. The pest risk analysis for fresh mango fruit from Taiwan was completed in August 2006. Existing policies for a number of pests of fresh mango fruit have now been included in this Report, where appropriate.

1.2.4. Transition into the regulated process

The Australian Government announced improvements to the IRA process on 18 October 2006. The new process applies to all IRA's announced by Biosecurity Australia on or after the commencement of the *Quarantine Amendment Regulations 2007 (No.1)* on 5 September 2007.

On 12 September 2007, Biosecurity Australia announced in Biosecurity Australia Policy Memorandum (BAPM) 2007/20 the transitional arrangements for its current import proposal work program. In the memorandum, stakeholders were advised that the import proposal for fresh mango fruit from India would be finalised under the regulated IRA process. It also advised that previous work or comparable steps already completed would not be repeated under the regulated process.

On 19 March 2008, Biosecurity Australia announced in Biosecurity Australia Advice (BAA) 2008/9 the formal commencement of an IRA under the regulated process to consider the proposal to import fresh mango fruit from India. It also advised that the analysis would be undertaken as a standard IRA requiring completion within 24 months. The IRA process is described in the *Import Risk Analysis Handbook 2007*.

Stakeholders were also advised that although the regulations allow a timeframe of 24 months to complete a standard IRA, in view of the significant body of work already undertaken, a provisional final IRA report was expected to be released by 30 June 2008.

1.2.5. Contaminating pests

In addition to the pests of fresh mango in India identified in the Report, there are other organisms that may arrive with the fruit. These organisms could include pests of other crops or predators and parasitoids of other arthropods. Biosecurity Australia considers these organisms to be contaminating pests that could pose sanitary and phytosanitary risks. These risks are addressed by standard operating procedures.

1.2.6. Consultation

In July 2004, Biosecurity Australia released a draft revised import policy report for stakeholder consideration containing pest risk assessments for the quarantine pests associated with fresh mango fruit from India (DAFF 2004). Comments were received from three stakeholders and incorporated into this report where appropriate. Australia has consulted with domestic and international stakeholders in preparing the final IRA report.

2. Method for pest risk analysis

In accordance with the International Plant Protection Convention, this technical component of a plant IRA is termed a 'pest risk analysis' (PRA). Biosecurity Australia has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2007a) and ISPM 11: *Pest Risk Analysis for Quarantine Pests, including analysis of environmental risks and living modified organisms* (FAO 2006a).

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 2007b). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2007b).

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 minimal on arrival verification procedures will apply. 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 2007b).

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

The PRA was conducted in the following three consecutive stages.

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.

The initiation point for this PRA was the receipt of a technical submission from the National Plant Protection Organisation (NPPO) for access to the Australian market for the commodity. This submission included information on the pests associated with the production of the commodity, including the plant part affected, and the existing commercial production practices for the commodity.

The pests associated with the crop and the exported commodity were tabulated from information provided by the NPPO of the exporting country and literature and database searches. This information is set out in Appendix A.

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 by the state or territory of Australia concerned.

For pests that had been considered by Biosecurity Australia in other risk assessments and for which import policies already exist, the need for new pest risk assessments was investigated to determine if a new pest risk assessment was required.

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 2007b).

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 identified in Stage 1 require a pest risk assessment. The categorisation process examines, for each pest, whether the criteria in the definition for a quarantine pest are satisfied. 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 2007b).

The pests identified in Stage 1 were categorised using the following criteria 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; and
- potential for economic consequences (including environmental consequences) in the PRA area.

The results of pest categorisation are set out in Appendix A. The quarantine pests identified during pest categorisation were carried forward for pest risk assessment and are listed in Table 4.2.

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 2006a). A summary of this process is given below, followed by a description of the qualitative methodology used in this IRA.

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 suitable host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its utilisation 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 Biosecurity Australia when estimating the probability of entry.

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

Probability of importation: the probability that a pest will arrive in Australia when a given commodity is imported; and

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;
- 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 life cycle 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; and
- 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 suitable 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 suitable hosts;
- Time of year at which import takes place;
- Intended use of the commodity (e.g. for planting, processing or consumption); and
- 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 2007b). In order to estimate the probability of establishment of a pest, reliable biological information (life cycle, host range, epidemiology, survival, etc.) should be 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 suitable hosts, alternative hosts and vectors;
- Suitability of the environment;
- Reproductive strategy and potential for adaptation;
- Minimum population needed for establishment; and
- 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 2007b). 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 should be obtained from areas where the pest currently occurs. The situation in the PRA area can then be 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;
- The potential for movement with commodities, conveyances or by vectors;
- Intended use of the commodity;
- Potential vectors of the pest in the PRA area; and
- 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, Biosecurity Australia 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 and their indicative probability ranges are given in Table 2.1. The indicative probability ranges illustrate the boundaries of the descriptors. The standardised likelihood descriptors and the associated indicative probability ranges provide guidance to the risk analyst and promote consistency between different risk analyses. However, these indicative probability ranges are not used beyond this purpose in qualitative PRAs.

Table 2.1: Nomenclature for qualitative likelihoods

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

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.

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.

Biosecurity Australia 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 Biosecurity Australia’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. Of course, if there are substantial changes in the volume and nature of the trade in specific commodities then BA has an obligation to review the risk analysis and, if necessary, provide updated policy advice.

In assessing the volume of trade in this PRA, Biosecurity Australia 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 2007b) and ISPM 11 (FAO 2006a).

Direct pest effects are considered in the context of the effects on:
Plant life or health; and
Other aspects of the environment.

Indirect pest effects are considered in the context of the effects on:
Eradication, control, etc.;
Domestic trade;
International trade; and
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.

Values were translated into a qualitative impact score (A–G)[2] using Table 2.3.

Table 2.3: Decision rules for determining the consequence impact score based on the magnitude of consequences at four geographic levels

Impact score	Local	District	Regional	National
G	Major significance	Major significance	Major significance	Major significance
F	Major significance	Major significance	Major significance	Significant
E	Major significance	Major significance	Significant	Minor significance
D	Major significance	Significant	Minor significance	Indiscernible
C	Significant	Minor significance	Indiscernible	Indiscernible
B	Minor significance	Indiscernible	Indiscernible	Indiscernible
A	Indiscernible	Indiscernible	Indiscernible	Indiscernible

Geographic level

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

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

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

2.2.4. Estimation of the unrestricted risk

Once the 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.

[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.

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					

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.

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 measure (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 2006a) 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 disinfestation 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 recommended for each quarantine pest where the risk exceeds Australia's ALOP. These are presented in the 'Pest Risk Management' section of this Report.

3. India's existing commercial production practices for fresh mango fruit

3.1. Assumptions used to estimate unrestricted risk

Biosecurity Australia took the following information on the existing commercial production practices into consideration when estimating the unrestricted risk of pests likely to be associated with fresh mango fruit imported from India. The existing commercial production practices, including vapour heat treatment facilities, were observed by officers from Biosecurity Australia in 2004. In April 2008, officers from Biosecurity Australia revisited India to verify the existing commercial production practices for export markets and observe the operation of an irradiation facility in Lasalgaon, India.

3.2. Production

Mangoes are grown commercially throughout the tropical and subtropical regions of India, to an altitude of 1500 m. Approximately 30 mango cultivars are grown commercially in India (Horticulture World 2003). The main commercial varieties are Alphonso, Banganapally, Chausa, Dashehari, Kesar and Totapuri (DAC 2007).

The State of Andhra Pradesh is the largest single mango growing region in India and produces approximately 29% of India's annual mango production. The total mango growing area in India is estimated to be 1.3 million hectares with an estimated production of 10.8 million tonnes per annum (Lal and Reddy 2002).

Figure 3.1: Kesar variety mango fruit in a commercial orchard in the State of Maharashtra, India

3.3. Exports

India's major mango export markets are the United Arab Emirates, Bangladesh, United Kingdom, Nepal, Canada and South Africa (DAC 2007). Minor markets include the European Union and Saudi Arabia (Chandra and Kar 2006). India has also signed protocols to export mangoes to Japan and has recently commenced exporting to the United States of America (2007) using irradiation (at 400 Gy) as a phytosanitary measure.

In 2004-05, exports of fresh Indian mango fruit were 50,000 tonnes, with a value of A$25 million (Chandra and Kar 2006).

3.4. Overview of cultivation practices and post-harvest management of fruit

The Agriculture and Processed Foods Export Development Authority (APEDA) has implemented an integrated production system to improve the quality of export fruit. It focuses on three major components: (i) orchard management, (ii) packing house and treatment procedures, and (iii) post-treatment cargo handling.

The orchards are required to be kept clean and well tended, with fallen fruit removed each day. Growers must attend and pass training sessions before their orchard is approved for export by the APEDA. Each state has a technical specialist and a number of extension officers who conduct regular orchard surveys for pests, and provide advice to growers on pest control measures.

Perishable cargo handling facilities used specifically for export produce are located in Mumbai and New Delhi. Both facilities have management systems for product identification, segregation, pest exclusion, and traceability.

3.4.1. Orchard management

An integrated pest management strategy is used to control pests affecting mango crops in the field. It includes cultural practices, mechanical practices, biological control and chemical control measures.

Some mango pests are host specific. For example, mango seed weevil mainly attacks the ‘Nellum’ and ‘Totapuri’ varieties. Therefore, many farmers are not planting these varieties in known mango seed weevil areas (DAC 2007).

Weeds are removed mechanically. Pests are exposed to natural predators and sunlight by directly disturbing the soil between and around individual mango trees (DAC 2007).

3.4.2. Pest specific integrated control measures

Fruit fly populations are minimised through the use of mass trapping techniques using traps containing one of two male lures, methyl eugenol or cue lure, combined with insecticide. Field control of adult fruit flies is also aided by the application of protein bait sprays commencing prior to the oviposition period and repeated at 15 day intervals. Immature stages are controlled by both deep burial of routinely collected fallen fruit and by ploughing the soil between trees to expose pupae.

Destruction of fallen fruits and disturbing soil around trees also helps in controlling mango weevils. The latter is used to expose overwintering weevils. Mango weevils are also controlled by applying chemical sprays three times; at the flowering stage, when the fruits are marble sized and finally when fruits are half grown.

Field control of scales and mealybugs is achieved through pruning affected twigs and branches in younger orchards. To prevent entry of mealybug nymphs from November to December each year, tree banding is conducted using 400 gauge polythene sheet 30cm above ground level. In addition, predatory lady beetles are used for biological control of mealybugs.

Lepidoptera are controlled by the removal of affected twigs and branches and by spraying a 2% solution of Neem (Azadirectin) at weekly intervals commencing from the flowering stage.

Fungi are controlled by the removal of affected twigs and branches in younger orchards and by spraying with copper oxychloride (0.2%) or Mancozeb (0.2%) initially at bud burst and another 15 days later.

3.4.3. Main cultivar groups

The important commercial varieties, production areas and mango fruit seasonality in India are summarised in Table 3.1. Production is largely counter seasonal to Australian production.

Table 3.1: Indian commercial mango fruit varieties, production states and seasons

		Months							
Variety	**Production States**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**
Alphonso	Andhra Pradesh, Goa, Gujarat, Karnataka, Maharashtra		■	■	■	■			
Banganpally	Andhra Pradesh, Karnataka, Orissa, Tamil Nadu			■	■	■	■	■	
Chausa	Bihar, Himachal Pradesh, Madhya Pradesh, Punjab, Uttar Pradesh					■	■	■	
Dashehari	Bihar, Haryana, Madhya Pradesh, Punjab, Uttar Pradesh				■	■	■		
Totapuri	Andhra Pradesh, Gujarat, Tamil Nadu, Karnataka				■	■	■		
Kesar	Gujarat, Maharashtra				■	■	■		

Source: DAC (2007)

3.4.4. Packing-house facilities

Receiving and unloading - Mango fruit from registered orchards is unloaded at the packing house facility. Each lot can be identified by the name of the orchard, a production unit code, variety and date of harvest to maintain traceability and prevent mixing of lots.

Pre-processing and inspection - Any damaged or diseased fruits received are segregated into crates and clearly marked ‘Rejected’ and moved to a separate storage area to prevent cross-contamination and mixing with export fruit. The reject storage area is separated from the pre-processing area by an insect proof screen.

3.4.5. Post-harvest processing

The process of cleaning, washing, hot water treatment, fungicidal dip and weighing/grading at the facility is carried out via an automated system. The fruit is moved through a treatment unit via adjustable speed roller conveyors. The thermostatically controlled hot water treatment unit is fully supervised and each process run is recorded.

Desapping – Fruit is initially placed with its stem end down on special plastic ‘desapping’ racks. Trained workers desap the mango fruit by holding them upside down and cutting the stem to 0.5 – 1.0 cm using sharp scissors.

Cleaning and washing – Cleaning of mango fruit is carried out through an automated washing system fitted with overhead sprayers and rotating brushes. Clean potable water is mixed with a detergent to strength of 0.1% and fruit is washed for a period of 3–5 minutes at 27ºC.

Hot water fungicidal dipping – Hot water treatment of fruit (Figure 3.2) is carried out in treatment tanks fitted with thermostatic controls to maintain a constant temperature of 52 ºC. The fungicide prochloraz at 500 ppm concentration is added. After this treatment the fruit is passed through a drying table and each fruit is wiped individually with a soft muslin cloth. The fruit is then transferred to a grading and sorting table.

Sorting and grading – At the sorting table, mangoes are sorted into export quality and other fruit. Any immature/scarred/blemished or otherwise damaged fruit are removed and loaded into plastic crates and labelled for disposal. Export quality mangoes are separated further according to size and weight (Fig. 3.3) into (i) Extra Class (ii) Class-1 and (iii) Class-2 as per the quality parameters specified by the APEDA.

Figure 3.2: Packing house facility for Indian mango fruit, showing hot water fungicidal treatment tank in foreground and washer unit in background

Figure 3.3: Weight sizing and grading conveyors for mango fruit

Packaging and Labelling – Each graded mango is placed into a soft, white expandable foam net sleeve to prevent bruising, and placed into compressed fibreboard cartons in a single layer (Figure 3.4). All ventilation holes are covered with insect proof mesh screening and all sides of the package are taped to prevent the entry of contaminating pests. Trays are labelled with the production unit code number, packing house code number, date and lot number and clearly show the 'Radura' irradiation symbol.

Figure 3.4: Alphonso variety mangoes post treatment in the packing house ready for transport to the irradiation treatment facility

Loading and transportation – Trays of mangoes (Fig. 3.5) are loaded into closed refrigerated trucks, sealed and transported directly to the irradiation facility for treatment. The loading area has a secure docking facility to prevent insect entry and cross-contamination.

Figure 3.5: Mango trays loaded onto a refrigerated truck ready for transport to the irradiation facility

Unloading and inspection – The truck is unloaded into a docking area, the door seal is broken by an Indian NPPO officer or an approved person, and lot numbers are validated.

Irradiation treatment – The mango trays are loaded in a 3×10 configuration (Fig. 3.6) into totes and treated at a minimum absorbed dose of 400 Gy using Cobalt 60 Gamma irradiation.

Figure 3.6: At the irradiation facility in Lasalgoan, Maharashtra, mango fruit are loaded into totes ready for treatment

Inspection and export - Treated fruit are then moved to a segregated storage area, inspected and certified by the NPPO, and loaded onto refrigerated trucks for transport to ports for export.

4. Pest risk assessments for quarantine pests

4.1. Quarantine pests for pest risk assessment

Pest risk assessments are presented in this section for the pests associated with mangoes that were found to be quarantine pests for Australia in the categorisation process in Appendix A. Pest risk assessment determines whether the risk posed by a pest achieves Australia's ALOP and whether phytosanitary measures are required to manage the risk.

Some of the organisms assessed here have been considered previously in other import policies and risk assessments already exist for these pests. For those pests that had been considered by Biosecurity Australia in other risk assessments and for which import policies already exist, the need for new pest risk assessments was investigated. Where appropriate, the previous policy has been adopted for these pests associated with mangoes from India. To highlight the pests for which policy already exists, the superscript 'EP' has been used. Additionally, some organisms identified in this assessment have been recorded in some regions of Australia but due to interstate quarantine regulations are considered pests of regional concern. These organisms are identified with a superscript of the state for which regional pest status is considered.

Pests requiring risk assessments are listed in Table 4.1. To simplify the assessment process, pests have been considered in groups where they are closely related and share similar biological characteristics, behaviour on the host and pathway, and potential phytosanitary considerations.

Table 4.1: Quarantine pests for mango fruit from India

Pest	Common name
Weevils [Coleoptera: Curculionidae]	
Sternochetus frigidus (Fabricius, 1787)	Mango pulp weevil
Sternochetus mangiferae (Fabricius, 1775)	Mango seed weevil ^{WA}
Fruit flies [Diptera: Tephritidae]	
Bactrocera caryeae (Kapoor 1971)	
Bactrocera correcta (Bezzi 1916)	Guava fruit fly
Bactrocera cucurbitae (Bezzi)	Melon fruit fly
Bactrocera dorsalis (Hendel, 1912)	Oriental fruit fly ^{EP}
Bactrocera invadens Drew, Tsuruta and White, 2005	Asian fruit fly
Bactrocera tau (Walter, 1909)	Pumpkin fruit fly
Bactrocera zonata (Saunders, 1841)	Peach fruit fly
Armoured scales [Hemiptera: Diaspididae]	
Abgrallaspis cyanophylli (Signoret, 1869)	Cyanophyllum scale $^{WA, EP}$

Parlatoria crypta (McKenzie, 1943)	Mango white scale
Mealybugs [Hemiptera: Pseudococcidae]	
Ferrisia malvastra (McDaniel, 1962)	Malvastrum mealybug [WA]
Ferrisia virgata (Cockerell, 1893j)	Striped mealybug [WA]
Planococcus lilacinus (Cockerell, 1905)	Coffee mealybug [EP]
Rastrococcus iceryoides (Green, 1908a)	Downy snowline mealybug
Rastrococcus invadens Williams 1986b	Mango mealybug
Rastrococcus spinosus (Robinson, 1918)	Philippine mango mealybug [EP]
Moths [Lepidoptera: Lymantriidae]	
Orgyia postica (Walker, 1855)	Cocoa tussock moth [EP]
Caterpillar [Lepidoptera: Pyralidae]	
Deanolis sublimbalis (Sneller, 1899)	Red-banded mango caterpillar
Thrips [Thysanoptera: Thripidae]	
Rhipiphorothrips cruentatus (Hood, 1919)	Mango thrips [EP]
Fungi	
Elsinoë mangiferae Bitancourt and Jenkins	Mango scab [EP, WA]
Fusarium mangiferae Britz, M.J., Wingf. and Marasas	Mango malformation

In the above table, WA = regional pest for Western Australia, and EP = existing policy exists for the organism

4.2. Mango pulp weevil – *Sternochetus frigidus* [Coleoptera: Curculionidae]

Mango pulp weevil is an important pest specific to cultivated and wild mango species and has a restricted distribution from the Indian subcontinent through South-East Asia to Indonesia (De Jesus *et al.* 2002). Mango pulp weevil has one generation per year, with the species completing the egg to adult cycle in 35–53 days (Srivastava 1997). The immature stages of the pest feed and develop in the pulp, and newly developed adults remain in a pupal cell inside the fruit until it rots (De Jesus *et al.* 2002). The eggs are white or pale yellow, the average length is 0.6 mm, and the average width is 0.28 mm (De and Pande 1988). In India, *Sternochetus* infestation may range from 65–100%, reducing the marketability of infested fruits (Dey and Pande 1987).

The species examined in this pest risk analysis is:
- *Sternochetus frigidus* – Mango pulp weevil.

4.2.1. Probability of entry

Probability of importation

The likelihood that mango pulp weevil will arrive in Australia with the importation of mango fruit from India is: **HIGH**.

Association of the pest with the pathway at its origin

- Mango pulp weevil has been reported in north-east India on cultivated and wild mango (Srivastava 1997; De Jesus *et al.* 2002). Fruit infestation rates of 65–80% and, at times 100% have been recorded for *Sternochetus* species in north-east India (Dey and Pande 1987).
- Adult mango pulp weevils feed on flowers, panicles and fruits. Eggs are laid singly on the developing mango fruit (Srivastava 1997). An incision is made in the fruit and eggs are covered with fruit exudate (De and Pande 1988). Infested fruit usually contain two to three eggs, although as many as seven eggs have been observed (Srivastava 1997).
- The newly hatched larvae tunnel into the fruit, where they develop (De and Pande 1988; Altoveros *et al.* 2001), feeding in the pulp as the fruit matures (Waite 2002).
- Approximately 30–50% of newly hatched larvae die through contact with gum laden tissues while they tunnel through the fruit pulp (CAB International 2007). Up to 20% of larvae die when the fruits are harvested, because they are unable to complete their development (CAB International 2007), but many larvae are unaffected.
- Infested fruit are difficult to detect as there are few external symptoms of infestation prior to exit of adult weevils from the ripe fruit through holes in the peel (CAB International 2007). Although all fruit is visually inspected during sorting and packing, the cryptic development of this species within mango fruit means current sorting practices are unlikely to detect invested fruit.

Ability of the pest to survive transport and storage

- As an internal pest feeding on mango fruit, mango pulp weevil is likely to survive during transport and storage.
- Mango pulp weevil completes a significant proportion of its life-cycle inside mango fruit. Larvae feed in the pulp of the mango fruit where pupation also occurs (De and Pande 1988; Srivastava 1997; De Jesus *et al.* 2002). Adult weevils may remain inside ripened

mango fruits for 37 days after pupation (Altoveros *et al.* 2001), and a large proportion of adults may hibernate (overwinter) inside mango fruits (De and Pande 1988).
- The mango pulp weevil has been intercepted on mangoes entering the USA (USDA 2006), demonstrating that it can survive transport and storage and could be imported into Australia via the movement of fruit.

Ability of the pest to survive existing pest management procedures
- The incidence of *Sternochetus* species can be reduced by field hygiene practices such as the removal of fallen fruits and leaves (Dey and Pande 1987).
- However, *Sternochetus* species have been detected in fruit in numerous countries, and intercepted by others, demonstrating that *Sternochetus* species can survive existing pest management procedures.

The ability of the pest to survive management procedures, its cryptic life-cycle inside the fruit and ability to develop there undetected for a considerable period supports an importation assessment of 'high'.

Probability of distribution

The likelihood that mango pulp weevil will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of mango fruit from India, is: **LOW**.

Ability of the pest to move from the pathway to a suitable host
- The mango pulp weevils associated with fruit are likely to be in the immature stage or adult life stage (De Jesus *et al.* 2002).
- The mango pulp weevils that survive cool storage (13˚C) would be capable of laying eggs, but a suitable host would need to be located. From the release of imported fruit at the point of entry to Australia, through to the retailing of fruit, there would be limited opportunities where suitable hosts are likely to be in close proximity to the imported commodity.
- Mango pulp weevils have a restricted host range (*Mangifera indica, M. sylvatica* and *M. foetida*) and develop slowly; the time from egg to adult takes 35–53 days, and only one generation is produced per year (Srivastava 1997).
- In Australia, some of these hosts can be found in domestic gardens, as well as in urban environments as amenity plants. This would limit the opportunity for reproductively active weevils to locate a suitable host.
- Adult weevils feed on mango flowers and mate and lay eggs on mango fruit when fruits are small to medium size (De Jesus *et al.* 2003). For counter-seasonal reasons, suitable sites for feeding may not be readily available when mango fruit is imported from India.
- The mango pulp weevil might enter the environment through:
  - eggs maturing into larvae within stored fruit, fruit at the point of sale, or fruit that has been purchased. The immature stages of the pest feed and develop in the pulp into adult weevils (De Jesus *et al.* 2005). Adult weevils may remain inside ripened mango fruits for several days (Altoveros *et al.* 2001). Some of the adult weevils may leave the fruit but some may hibernate within it (De and Pande 1988). Newly emerged adults are able to move directly from the fruit into the environment.
  - wholesalers, retailers or consumers discarding fruit with spoiled flesh or visible larvae. Adult *Sternochetus* can emerge from the discarded fruit but rarely move far from the point of emergence (Shukla and Tandon 1985). Adults may transfer to a suitable host by crawling (preferred) (De Jesus *et al.* 2003), or flying (Srivastava 1997). However, flight is limited to a distance of 50–90 cm in a horizontal direction (Srivastava 1997).

Distribution of the imported commodity in the PRA area

- The commodity is likely to be distributed to retail destinations throughout Australia for sale.
- Eggs could develop into larvae, and larvae to adult weevils within fruit throughout the distribution chain. The ability to pupate or even hibernate in fruit gives the weevil the ability to survive distribution within Australia.
- Wholesalers, retailers or consumers could discard spoiled fruit containing eggs or larvae or adults at multiple locations.

Risks from by-products and waste

- The intended use of the commodity is for human consumption but waste material will be generated. Infested fruits show no signs of infestation when ripe, despite the immature life stages feeding and pupating inside the mango (Altoveros *et al.* 2001). Larvae in infested mangoes could complete development in discarded waste.
- Adults are able to survive for some time in the absence of food sources (De and Pande 1988). Female weevils, for example, are able to survive up to 82 days without food (De and Pande 1988).

The limited flying ability of adults, and the limited number of hosts in close proximity to distribution outlets in the temperate areas of Australia supports a distribution assessment of 'low'.

Probability of entry (importation x distribution)

The overall probability of entry for mango pulp weevil is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for mango pulp weevil is estimated to be: **LOW**.

4.2.2 Probability of establishment

The likelihood that mango pulp weevil will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **MODERATE**.

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- The mango pulp weevil is capable of surviving and reproducing on *Mangifera indica, M. sylvatica* (Srivastava 1997) and *M. foetida* (CAB International 2007).
- *Mangifera* species are commonly grown in tropical and subtropical areas of Australia, including major cities (Brisbane, Darwin, Sydney and Perth), as ornamental, shade and fruit trees.
- Transport of infested fruits containing adults or immature stages of *S. frigidus* is likely to be the major means of dispersal to uninfected areas, as has been found for the similar species *S. mangiferae* (Pinese and Holmes 2005).

Suitability of the environment

- Mango pulp weevil has a distribution from India to Indonesia (De Jesus *et al.* 2002; CAB International 2007). There are parts of Australia that have similar climatic conditions to countries where it already thrives. *Sternochetus* species could establish in any climate suitable for mango production (USDA 2006). Optimum temperatures for the development of mango pulp weevil are from 21–27°C (Srivastava 1997).
- *Sternochetus mangiferae* (mango seed weevil), a closely related species, is already established in tropical and subtropical parts of eastern Australia (Smith 1996).

Cultural practices and control measures

- Control of *Sternochetus* species with insecticides has been shown to be difficult and impractical (Dey and Pande 1987). The implementation of clean cultivation (removal of fallen fruits and leaves) and soil disturbance has been shown to reduce infestations from 87% to 68–78% (Dey and Pande 1987). These practices, if implemented, would reduce but not eliminate the probability of establishment.

The reproductive strategy and survival of the pest

- Mango pulp weevils reproduce sexually (De and Pande 1988). At full-bloom stage the adult weevils crawl on flowers to feed. When fruits are small to medium in size they become the mating and oviposition sites (De Jesus *et al.* 2003).
- Mating occurs 10–15 days following emergence from hibernation (Srivastava 1997). Females lay about 15 eggs in a day, and up to a maximum of 115 eggs in a three week period (De and Pande 1988).
- The time from egg to adult is 35–53 days and only one generation is produced per year (Srivastava 1997). This limits the ability of the weevils to establish populations if conditions are suitable only in small 'windows of opportunity'.
- Mango pulp weevil can survive as adult weevils in the fruit (De and Pande 1988). Female weevils are able to survive up to 82 days without food, and longer when food is provided (De and Pande 1988). Up to 58% of adult weevils of this species may hibernate inside mango fruit (Srivastava 1997). The remaining weevils undergo hibernation beneath fallen fruits, in leaf litter, in crevices and in refuse material discarded in the orchard (Srivastava 1997).

The long generation time (one year) allows this weevil to survive until the next flowering period and the fact a closely related species has already established in Australia supports an establishment rating of 'moderate'.

4.2.3. Probability of spread

The likelihood that mango pulp weevil will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **MODERATE**.

The suitability of the natural or managed environment for natural spread

- Many environments (natural and cultivated) within Australia mirror those in countries where the weevil already thrives.
- Mango pulp weevils survive as adults hibernating inside mango fruit or beneath fallen fruits, in leaf litter, in crevices and in refuse material discarded in the orchard (Srivastava 1997; De and Pande 1988).
- Current mango pulp weevil management programs (clean cultivation, removal of fallen fruits and leaves) may have some impact on reducing the spread rate of mango pulp weevil (Dey and Pande 1987).

Presence of natural barriers

- The presence of natural barriers such as deserts or mountain ranges may prevent long-range natural spread of mango pulp weevil to widely dispersed mango production areas. Adult weevils are capable of flight, but are poor fliers only covering distances less than one metre in horizontal directions (De and Pande 1988). Therefore adult weevils will move only a limited distance by natural dispersal. Adult weevils usually hibernate in the vicinity of the original infestation until the following fruiting season (De and Pande 1988).

Potential for movement with commodities or conveyances

- The major means of dispersal to uninfected areas is likely through transport of infested fruits containing adults or immature stages of the pest, as has been found for the similar species *S. mangiferae* (Pinese and Holmes 2005). Movement of infected fruit by human transport is generally a significant means of dispersal (Baker *et al*. 2000).
- Mango pulp weevil has demonstrated a capacity to spread, from its original range in the India-Myanmar region where mango is native, to Indonesia and Papua New Guinea (De Jesus *et al.* 2002; CAB International 2007).
- Existing interstate and intrastate quarantine control on the movement of nursery stock and other plant material could reduce the rate of spread.

Potential natural enemies

- Natural enemies of mango pulp weevil include the parasitic wasp *Flavopimpla mangae* and ngrangrang ants (*Oecophylla* species), which repel most insects in the vicinity of their nest and are able to keep a tree free from weevil infestation (CAB International 2007). *Camponotus* species of ants can also disturb adult weevils. Larvae, pupae and hibernating adults can be parasitised by *Rhizoglyphus* species (De and Pande, 1988). No information is available on potential natural enemies that may be present in Australia.

Restricted host range (mango varieties) and limited natural dispersal ability (poor fliers), balanced by an ability to move with commodities, support a spread rating of 'moderate'.

4.2.4. Overall probability of entry, establishment and spread

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

The overall probability that mango pulp weevil will be imported as a result of trade in mango fruit from India, be distributed in a viable state to a suitable host, establish and spread within Australia, is: **LOW**.

4.2.5. Consequences

The consequences of the entry, establishment and spread of mango pulp weevil in Australia have been estimated according to the methods described in Table 2.3. The assessment of potential consequences is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D** – Significant at the district level. This pest can cause significant direct harm to mango production at the district level. • The mango pulp weevil feeds and pupates in the flesh of the fruit, resulting in a reduced market value of infested fruits (Dey and Pande 1987; De and Pande 1988). • Losses are not restricted to the mango fruit industry as mango pulp weevil also causes quality control issues to the mango-processing industry (Thomas *et al.* 1995).
Other aspects of the environment	**A** – Indiscernible at the local level There are no known direct consequences of this pest on other aspects of the environment. The host range of mango pulp weevil is limited to mango species (Srivastava 1997).

Indirect	
Eradication, control etc.	**D** – Significant at the district level. A control program would have to be implemented in infested orchards to reduce fruit damage and yield losses, and this would increase production costs. Imported mango fruit from countries where mango pulp weevil occurs may be subjected to a quarantine treatment. • Control of Mango Pulp Weevil with insecticides has been shown to be impractical (Dey and Pande 1987). • Clean cultivation and soil disturbance has been shown to reduce infestations (Dey and Pande 1987).
Domestic trade	**D** – Significant at the district level The presence of mango pulp weevil in commercial production areas may trigger interstate trade restrictions on mango fruit movement. These restrictions may lead to a loss of markets and industry adjustment.
International trade	**E** – Significant at the regional level. The presence of mango pulp weevil in commercial production areas of Australia is likely to limit access to overseas markets where this pest is absent. Other countries impose phytosanitary restrictions on the movement of mango fruit due to the presence of mango pulp weevil to prevent the spread of this weevil into their mango production areas (Dey and Pande 1987).
Environmental and non-commercial	**A** – Minor significance at the local level. It is unlikely that insecticides would be used to control mango pulp weevil, so its consequences would be indiscernible for the environment.

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

4.2.6. Unrestricted risk estimate

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

Unrestricted risk estimate for mango pulp weevil	
Overall probability of entry, establishment and spread	**Low**
Consequences	**Moderate**
Unrestricted risk	**Low**

As indicated, the unrestricted risk for mango pulp weevil has been assessed as 'low', which is above Australia's ALOP. Therefore, specific risk management measures are required for this pest.

4.3. Mango seed weevil – *Sternochetus mangiferae* [Coleoptera: Curculionidae]

This analysis considers the following species which is of quarantine significance to Western Australia:

- *Sternochetus mangiferae* – Mango seed weevil **WA**.

Mango seed weevil is a monophagous pest which attacks mango varieties and cultivars (Srivastava 1997). Infested fruits show no sign of infestation when ripe despite the immature life stages feeding and pupating inside the mango seed (Srivastava 1997). The species is generally considered to be a pest of the seed and records of this species feeding or developing in the mango pulp are rare (Hansen *et al.* 1989; Follet and Gabbarv 2000).

Adult weevils are dark brown to black with grey markings and are 6–9 mm long. Weevils spend the winter living under loose bark around the base of mango trees or in the forks of branches (Pinese and Holmes 2005). They may also live in leaf litter around the tree, and approximately 25% of the adults overwinter in seed. Adult weevils can live for two years, so even with a crop failure in one season some weevils can survive into the following year (Pinese and Holmes 2005). Mango seed weevil has one generation per year (Pena *et al.* 1998; Verghese *et al.* 2005a) completing the egg to adult cycle in 1–2 months (Shukla and Tandon 1985; Srivastava 1997).

4.3.1. Probability of entry

Probability of importation

The likelihood that mango seed weevil will arrive in Western Australia with the importation of mango fruit from India is: **HIGH**.

Association of the pest with the pathway at its origin

- The mango seed weevil is considered to be a serious pest throughout its range in India (Srivastava 1997), including Andhra Pradesh, Orissa, Tamil Nadu, Karnataka, Kerala, Maharashtra and Gujarat (Shukla and Tandon 1985). Infestation of fruit by this weevil is known to reach up to 100% in some mango varieties (Vereesh 1989).
- Eggs are laid in a depression on the surface of fruits and covered with a fruit exudate (Follet and Gabbard 2000). Initially the oviposition site is seen as a brownish spot on the rind but this heals and the spot fades as the fruit ripens (Smith 1996; Pinese and Holmes 2005).
- Larvae tunnel into immature fruit before the seed endocarp thickens (Follett and Gabbard 2000). As the fruit matures the seed coat becomes hard; hampering the weevil's ability to tunnel into the seed and leading to higher morality of first instar larvae (Shukla and Tandon 1985; Hansen *et al.* 1989). Larvae feed within the seed and pupate in the seed cavity (Follett 2002). Complete larval development usually occurs within the maturing seed, but also occasionally within the flesh (Hansen *et al.* 1989). Infested seeds usually contain one or two weevils, but seeds containing six or more have been recorded (Balock and Kozuma 1964; Srivastava 1997).
- Infested fruit is difficult to detect as there are no external symptoms of infestation (Cunningham 1989; Srivastava 1997). Cutting fruit open for weevil presence is an effective method of detection (Shukla and Tandon 1985). Fruit inspection procedures are concerned primarily with quality standards of fruit with regard to blemishes, bruising or

damage to the skin and are not specifically directed at the detection of internal pests that may be feeding under the skin of the fruit.
- Mango seed weevil larvae can survive in picked fruit and are likely to be present in fruit that is packed for export.

Ability of the pest to survive transport and storage

- As an internal pest feeding on mango fruit, mango seed weevil could survive during transport and storage.
- Weevils tunnel inside the seed of mango fruits and destroy the cotyledons (Cunningham 1989). Pupation occurs inside the fruit and adults usually emerge within two months of fruit fall, but it may be longer (Cunningham 1989).
- Adults are able to survive for considerable periods of time in the absence of food sources (Srivastava 1997). In the related species *S. gravis*, female weevils are able to survive for 82 days without food, and 135 days with food and water (De and Pande 1988). In plantations, weevils may hide in bark, crevices and other niches during hibernation (Balock and Kozuma 1964; Shukla and Tandon 1985; Srivastava 1997; Verghese *et al.* 2005a).
- Mango seed weevil may survive for more than two years when provided with food (mango fruit) and water (Balock and Kozuma 1964; Srivastava 1997; Follett 2002). Mango seed weevil has been recorded to survive for two seasons with a hibernation period between these seasons (Balock and Kozuma 1964).
- The mango seed weevil has been intercepted on mango entering the USA (USDA 2006), indicating that it would survive transport and storage and be imported into Western Australia via the movement of fruit.

Ability of the pest to survive existing pest management procedures

- The incidence of *Sternochetus* species can be reduced by field hygiene, for example removing fallen fruits and leaves (Dey and Pande 1987; Smith 1996).
- However, *Sternochetus* species have been detected in fruit in numerous countries, and intercepted by others, demonstrating that *Sternochetus* species can survive existing pest management procedures.

The ability of the pest to survive management procedures, its cryptic lifestyle inside the fruit and ability to develop there undetected for a considerable period supports an importation assessment of 'high'.

Probability of distribution

The likelihood that mango seed weevil will be distributed to Western Australia in a viable state, as a result of the processing, sale or disposal of mango fruit from India, is: **LOW**.

Ability of the pest to move from the pathway to a suitable host

- The mango seed weevils associated with fruit are likely to be in the immature stage or adult life stage (De and Pande 1988; Smith 1996).
- The mango seed weevils that survive cold storage would be capable of laying eggs, but a suitable host would need to be located to establish a founding population. From the release of imported fruit at the point of entry to Australia, through to the retailing of fruit, there would be limited opportunities where suitable hosts are likely to be in close proximity to the imported commodity.
- Mango seed weevils have a restricted host range (*Mangifera indica* and its varieties (Srivastava 1997) and develop slowly; the time from egg to adult takes 35–54 days (Shukla and Tandon 1985) and only one generation is produced per year (Pinese and Holmes 2005).

- In Australia, these hosts can be found in domestic gardens, as well as in urban environments as amenity plants. Adults move into the outer canopy of the tree during flowering to feed on new growth and mate prior to egg laying (Smith 1996). For counter-seasonal reasons, suitable sites for feeding may not be readily available when mango fruit is imported from India. This would limit the opportunity for reproductively active weevils to locate a suitable host.
- The mango seed weevil might enter the environment through two scenarios.
  - Eggs, larvae, pupae or adults may be present in fruit at the point of sale, or fruit that has been purchased. Larvae may then develop into adults, which are able to move directly from the fruit into the environment.
  - Consumers may discard seed containing adults. Often only one adult will mature in each seed (Balock and Kozuma 1964; Follett 2002) but as many as six individuals may be present in some varieties (Srivastava 1997). Adults can emerge from the discarded seed and transfer to suitable hosts by crawling or flying (Shukla and Tandon 1985).
- The adults are known to be poor fliers (Pinese and Holmes 2005), limiting the ability of mango seed weevil to move onto a suitable host from discarded fruit.

Distribution of the imported commodity in the PRA area

- The commodity is likely to be distributed to multiple destinations throughout Western Australia for retail sale.
- Eggs may develop into larvae and larvae to adults within fruit throughout the distribution chain. Consumers could discard seeds containing eggs or adults at multiple locations.

Risks from by-products and waste

- Waste material would be generated in the course of consumption. Infested fruits show no signs of infestation when ripe despite the immature life stages feeding and pupating inside the mango (Smith 1996; Srivastava 1997). When infested seed is disposed of, larvae are still likely to complete development.
- Adults are able to survive for considerable periods of time in the absence of food sources (Srivastava 1997). In the related species *S. frigidus*, female weevils are able to survive for 82–135 days without food (De and Pande 1988).

The limited flying ability of adults, and the limited number of hosts in close proximity to distribution outlets in the temperate areas of Western Australia supports a distribution assessment of 'low'.

Probability of entry (importation x distribution)

The overall probability of entry for mango seed weevil is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for mango seed weevil is estimated to be: **LOW**.

4.3.2. Probability of establishment

The likelihood that mango seed weevil will establish in Western Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **MODERATE**.

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- Mango seed weevil is capable of surviving and reproducing on *Mangifera indica* and its varieties (Srivastava 1997). Laboratory tests have demonstrated that the weevil either fails to lay eggs or cannot complete its development on other hosts (Balock and Kozuma 1964).

- *Mangifera* species are grown widely in tropical and subtropical areas of Western Australia as ornamental, shade and fruit trees.
- Wild and backyard mango trees are considered to be a continuous source of mango seed weevil in infected areas in Hawaii (Hansen *et al.* 1989).

Suitability of the environment

- Mango seed weevil, native to the Indo-Myanmar region (Follet 2002), now has a distribution extending to southern and eastern Africa, most Asian countries, parts of the South Pacific and Hawaii (Cunningham 1989, Smith 1996). Western Australia has similar environments that would be suitable for the establishment of this pest. This is supported by the fact that mango seed weevil is already established in New South Wales, the Northern Territory and Queensland (Smith 1996)
- *Sternochetus* species could presumably establish in any climate suitable for mango production (USDA 2006). Limiting factors include its monophagy and sensitivity to temperature and humidity: the optimum temperature for the development of mango seed weevil is 24°C (De and Pande 1988).

Cultural practices and control measures

- Because the weevil is an internal pest of the fruit, current insecticide spray regimes for other pests may not have any impact on the establishment of mango seed weevil in Western Australia.
- No parasites or other biocontrol agents have been identified for the species (Follett and Gabbard 2000; Verghese *et al.* 2005b).

The reproductive strategy and survival of the pest

- Mango seed weevils reproduce sexually (Smith 1996). During flowering the adult weevils leave their shelter areas under loose tree bark or litter under the trees, and move into the outer canopy of the tree to feed on new growth and to mate prior to egg laying (Pinese and Holmes 2005).
- Eggs are laid on small to medium sized fruit, but when populations are high, full size fruit can also be utilized (Smith 1996). Adult females may lay up to 15 eggs per day and can deposit almost 300 eggs over a three month period (Smith 1996). Reproduction is triggered by mango trees coming into flower (Peña *et al.* 1998).
- After 5–7 days, the first instar larvae hatch from the egg and burrow through the mango flesh to the soft, developing seed. The seed is often completely destroyed by the feeding activity of two or more larvae. After the fruit matures and falls to the ground (or is harvested), the adult weevils chew a hole through the seed covering to emerge. This can occur between 22 and 76 days after fruit drop, but averages 45 days (Smith 1996).
- After emergence, adults enter a diapause, which varies in duration with the geographic range. For example, in southern India, all adults emerging during June enter a diapause from July until late February of the following year (Shukla and Tandon 1985). The onset and termination of diapause appear to be associated with long-day and short-day photoperiod, respectively (Balock and Kozuma 1964).
- The time from egg to adult is 35–54 days (Shukla and Tandon 1985) and only one generation is produced per year (Smith 1996; Peña *et al.* 1998; Follett 2002; Verghese *et al.* 2005a). This limits the ability of the weevils to establish populations if conditions are suitable only in small ‘windows of opportunity’.
- Mango seed weevils overwinter as adults in the fruit, under loose bark around the base of mango trees or in the forks of branches or in litter under mango trees (Shukla and Tandon 1985; Pinese and Holmes 2005).
- Mango seed weevils are long lived and may survive for more than two years when provided with food (mango fruit) and water (Balock and Kozuma 1964; Srivastava 1997;

Follett 2002). Mango seed weevils have been recorded to survive for two seasons with a hibernation period between these seasons (Balock and Kozuma 1964).

The long generation time (one year) allows this weevil to survive until the next flowering period and the fact this weevil has established in eastern Australia supports an establishment rating of 'moderate'.

4.3.3. Probability of spread

The likelihood that mango seed weevil will spread within Western Australia, based on a comparison of those factors in source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **MODERATE**.

The suitability of the natural or managed environment for natural spread

- Mango seed weevil has been reported from tropical and subtropical environments in various countries, including eastern Australia (New South Wales, Northern Territory and Queensland). There are similarities in the natural and built environments of these states with those in Western Australia. This suggests that mango seed weevil would be able to spread within Western Australia.
- Mango seed weevils survive as adults hibernating in the fruit, under loose bark around the base of mango trees or in the forks of branches or in litter under mango trees (Shukla and Tandon 1985; Pinese and Holmes 2005). Once they emerge from the mango seed, mango seed weevils usually stay in close proximity to their host tree until the following fruiting season.
- Mango seed weevil displays clumping distributions with large infestations appearing year after year at the same location and low infestations at other locations. In some areas in Australia, mango seed weevil infests more than 80% of fruit (Cunningham 1991).
- Current mango seed weevil management programs in Australia (vigilance, hygiene, chemical control) may have some impact on reducing the spread rate of mango seed weevil (Smith 1996).

Presence of natural barriers

- The presence of natural barriers such as deserts or mountain ranges may prevent long-range natural spread of mango seed weevil. Although the adult weevils are capable of flight, they are not strong fliers (Smith 1996). It is unknown how important flight is in the dispersal of the species.
- The long distances between some of the main West Australian commercial mango production areas may make it difficult for this pest to disperse unaided from one production area to another. Adult weevils usually remain in the vicinity of the original infestation until the following fruiting season (Cunningham 1991).
- Hosts of mango seed weevil are widely distributed in Western Australia. The long distances between commercial host crops in Western Australia may prevent long-range natural spread of mango seed weevil.

Potential for movement with commodities or conveyances

- The major means of dispersal to uninfected areas is through transport of adults and immature stages in infested fruits (Pinese and Holmes 2005).
- There are restrictions in place in Australia on the movement of fruit to prevent the spread of mango seed weevil into Western Australia. Domestic quarantine regulations require that mango fruit entering Western Australia is sourced from properties free from *Sternochetus mangiferae* and requires a sample of the fruit to be dissected and inspected for the presence of the weevil.

- Mango seed weevil has demonstrated a capacity to spread, from its original range in the India-Myanmar region to many mango growing countries (Smith 1996).
- Existing interstate quarantine control on the movement of nursery stock and other plant material could inhibit spread into Western Australia, but would be of limited use within the state where control measures may not be applied.

Potential natural enemies

- Predators of mango seed weevil are known, but all fail to control populations of the pest in the field (Verghese *et al.* 2005b). No parasites or other biocontrol agents have been identified for the species (Follett and Gabbard 2000; Verghese *et al.* 2005b).

Restricted host range (mango varieties) and limited natural dispersal ability (poor fliers), balanced by an ability to move with commodities, support a spread rating of 'moderate'.

4.3.4. Overall probability of entry, establishment and spread

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

The overall probability that mango seed weevil will be imported as a result of trade in mango fruit from India, be distributed in a viable state to a susceptible host, establish and spread within Western Australia, is: **LOW**.

4.3.5. Consequences

The consequences of the entry, establishment and spread of mango seed weevil in Western Australia have been estimated according to the methods described in Table 2.3. The assessment of potential consequences is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D** – Significant at the district level. This pest can cause significant direct harm to mango production at the district level. • Losses of 5–80% have been recorded, including losses due to premature fruit drop caused by mango seed weevil (Verghese *et al.* 2005a). • Losses are not restricted to the mango fruit industry as mango seed weevil also causes quality control issues to the mango-processing industry (Thomas *et al*. 1995).
Other aspects of the environment	**A** – Indiscernible at the local level. There are no known direct consequences of this pest on other aspects of the environment. The host range of mango seed weevil is limited to mango (Srivastava 1997).
Indirect	
Eradication, control etc.	**D** – Significant at the district level. A control program would have to be implemented in infested orchards to reduce fruit damage and yield losses, and this would increase production costs. Imported mango fruit from countries where mango seed weevil occurs may be subjected to a quarantine treatment. • In India, field sanitation and other cultural methods reduced infestation by up to 19% (Dey and Pande 1987). • Research into field sanitation, natural enemies and host plant resistance as control methods have had little success (Follett and Gabbard 2000). Chemical control programs for mango seed weevil are believed to be the best option for pest management (Verghese *et al.* 2005b), adding additional costs to mango production.

Domestic trade	**B** – Minor significance at the local level. It is doubtful that there would be any resulting interstate trade restrictions on host plants and plant material as mango seed weevil is present in other states.
International trade	**E** – Significant at the regional level. The presence of mango seed weevil in commercial production areas of Western Australia is likely to limit access to overseas markets where this pest is absent. • Many countries impose phytosanitary restrictions on the movement of mango fruits due to the presence of mango seed weevil (Follett and Gabbard 2000). In the USA, mango fruit is prohibited into Florida from Hawaii (Follett and Gabbard 2000). • The USA and several Middle Eastern countries impose quarantine restrictions on the importation of mango fruit from infested areas in Australia (Smith 1996).
Environmental and non-commercial	**B** – Minor significance at the local level. Although additional insecticide applications would be required to control mango seed weevil, this is considered to have minor significance for the environment.

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

4.3.6. Unrestricted risk estimate

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

Unrestricted risk estimate for mango seed weevil	
Overall probability of entry, establishment and spread	**Low**
Consequences	**Moderate**
Unrestricted risk	**Low**

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

4.4 Fruit flies [Diptera: Tephritidae] – mangoes as a preferred host

Fruit flies are considered to be among the most damaging pests to horticulture (White and Elson-Harris 1992; Peña *et al.* 1998). Fruit flies in the genus *Bactrocera* are one of four fruit fly genera that are of most global concern. *Bactrocera* species are an economically important and diverse genus of fruit flies, having in excess of 400 recognised species (White and Elson-Harris 1992). They have an ability to rapidly increase in population and a great ability to disperse successfully and therefore represent a significant threat to agriculture not only in their current global distribution but also by establishing in new countries (Fletcher 1989a; Fletcher 1989b). *Bactrocera* spp. attack a wide range of fruit including tropical, semitropical and temperate fruit in South-East Asia, Oceania, the subcontinent and parts of Africa.

Fruit flies are of concern because their larvae generally complete their feeding and development within the host fruit (Fletcher 1989a). Fruit with infestation normally show obvious signs of attack or tissue decay. However, infested fruit cannot always be distinguished from uninfested fruit (White and Elson-Harris 1992). The transportation of infested fruit is regarded as the major means of movement and dispersal of fruit flies (Baker *et al*. 2000; Iwaizumi 2004) and therefore deserves the most scrutiny in terms of pathways for introduction.

The fruit flies of quarantine concern associated with mango fruit are:

- *Bactrocera caryeae*
- *Bactrocera correcta* – guava fruit fly
- *Bactrocera dorsalis* – Oriental fruit fly **EP**
- *Bactrocera invadens* – Asian fruit fly
- *Bactrocera zonata* – peach fruit fly

Oriental fruit fly, *Bactrocera dorsalis* has previously been assessed for the importation of mangoes from Taiwan and had an unrestricted risk of **High**. This existing policy is adopted for this fruit fly as the risks of importation and distribution are judged to be similar. Therefore, oriental fruit fly is not considered further in this policy.

Bactrocera caryeae, B. correcta, B. invadens and *B. zonata* considered in this assessment are recognised as pests of mango in India. *Bactrocera zonata* is similar to *B. dorsalis* in terms of its broad host range preferences. *Bactrocera zonata* may be a hybrid or intermediate form resulting from a cross of *B. dorsalis* and *B. correcta* (Gomes 2000). *Bactrocera caryeae* has a more restricted host range (White & Elson-Harris 1992) and *Bactrocera invadens* is morphologically very similar to *B. dorsalis* (Drew *et al.* 2005). This species appears to have recently invaded Africa from the Indian subcontinent where it is of significant economic importance (Drew *et al.* 2005). The biology of *Bactrocera caryeae, B. correcta, B. invadens* and *B. zonata* was considered sufficiently similar to justify combining them into a single assessment.

4.4.1 Probability of entry

Probability of importation

The likelihood that fruit flies will arrive in Australia with the importation of mango fruit from India is estimated to be: **HIGH**.

Association of the pest with the pathway at its origin

- *Bactrocera caryeae*, *B. correcta*, *B. invadens* and *B. zonata* have been reported on mangoes in India (Peña *et al.* 1998; Kumar and Bhatt 2002; Drew and Raghu 2002; Hanna 2005).
- In the mango production regions of India, adults of *B. correcta* and *B. zonata* occur throughout the year and abundance increases during mango ripening and harvest (Srivastava 1997; Peña *et al.* 1998). Up to 100% of fruit can be infested in unmanaged orchards (Stonehouse *et al.* 1998).
- Fruit fly larvae can survive in harvested fruit and may be present in fruits that are packed for export. As fruit fly eggs are laid internally, infested fruit may not be detected during sorting, packing and inspection procedures. Inspection procedures carried out in the packing houses are concerned primarily with quality standards of fruit with regard to blemishes, bruising or damage to the skin.

Ability of the pest to survive transport and storage

- The optimum temperature for storage of mangoes is approximately 13-14°C, as storage below this temperature results in chilling injury to the fruit (Lederman et al. 1997; Nair and Singh 2004). At low temperatures, development times for fruit flies are extended significantly and mortality increases for all life stages (Duyck *et al.* 2004). Although development thresholds have not been reported for all species considered here, Duyck *et al.* (2004) reported that the lower development thresholds for *B. zonata* eggs, larvae and pupae are 12.7, 12.6 and 12.8°C respectively. Mohamed (2000, as cited in Duyck *et al.* 2004) calculated lower temperature thresholds of 10, 10 and 11.8°C for the egg, larval and pupal stages of *B. zonata* respectively. Therefore, immature stages could continue to develop at the optimum storage temperature of 13-14°C.
- *Bactrocera caryeae* has been intercepted on mango from India in Japan (Iwaizumi 2004). *Bactrocera correcta* has been detected during surveillance in California and Florida in the USA (Weems 1987, Weems 2001). In commercial consignments of mango, *B. zonata* has been intercepted from Pakistan and *B. invadens* from Senegal in the United Kingdom (DEFRA 2008). This further supports that *Bactrocera* species can survive transport and storage and could be imported into Australia via the movement of fruit.

Ability of the pest to survive existing pest management procedures

- *Bactrocera* species are typically managed in India by trapping, bait sprays and collection and deep burial of fallen fruit (DAC 2007). These methods will reduce but not necessarily eliminate populations.

The ability of fruit flies to survive management procedures, the difficulty of detecting them within fruit, their ability to survive transportation and storage temperatures and the history of their interceptions supports a probability of importation rating of 'high'.

Probability of distribution

The likelihood that fruit flies will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of mango fruit from India is: **HIGH**.

Ability of the pest to move from the pathway to a suitable host

- Fruit fly eggs or larvae infested fruit arriving in Australia would still need to develop into mature larvae and pupate. Fruit flies develop quickly, with a wide host range and excellent dispersal capabilities (Fletcher 1989a, 1989b).

- Mango fruit from India would be imported during the winter months in Australia. At this time, the coastal regions of Australia north of Sydney may have suitable temperatures to allow the slow development of larvae and pupae (Duyck *et al.* 2004).
- Most *Bactrocera* species have a wide host range including horticultural crops and ornamentals (Srivastava 1997; Allwood *et al.* 1999), and these hosts are widely distributed throughout Australia.
- Fruit flies might enter the environment through:
  - eggs developing into larvae within stored fruit, fruit at the point of sale, or fruit that has been purchased. Larvae may then develop into adult flies which are able to move directly into the environment.
  - wholesalers, retailers or consumers discarding fruit with spoiled flesh or visible larvae. Infested fruit typically contains several larvae (Kumar and Bhatt 2002) which can complete larval development in discarded fruit, pupate in soil and adults can then transfer to suitable hosts (Fletcher 1987).

Distribution of the imported commodity in the PRA area

- Mangoes would be distributed for sale to multiple destinations in Australia.
- Eggs may develop into larvae within fruit throughout the distribution chain. Wholesalers, retailers or consumers could discard spoiled fruit containing eggs or larvae at multiple locations.

Risks from by-products and waste

- The intended use of the commodity is human consumption but waste material would be generated. Larvae could complete development in waste material.
- Newly emerged adults contain some energy reserves carried over from the larval stage, which enables them to survive for 1–2 days post-emergence if food is not available (Fletcher 1987).
- Larvae develop into adult flies and are able to move directly from fruit into the environment to find a suitable host. Adult flies typically live for periods of months (Christenson and Foote 1960; Fletcher 1989b).

Their wide host-ranges, their ability to tolerate cold temperatures and their natural dispersal ability (strong flier) support a distribution rating of 'high'.

Probability of entry (importation x distribution)

The overall probability of entry for fruit flies is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for fruit flies is estimated to be: **HIGH**.

4.4.2 Probability of establishment

The likelihood that fruit flies will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **HIGH.**

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- These fruit flies are capable of surviving and reproducing on a wide host range, including citrus, mango, peach and several other subtropical fruits (White and Elson-Harris 1992; Allwood *et al.* 1999; Hanna 2005). These host species are widespread in cities, towns and horticultural production areas throughout Australia.
- *Bactrocera correcta* has the potential to become a pest of citrus and peach, as well as several other subtropical fruits (Weems 1987; Allwood *et al.* 1999). *Bactrocera invadens*

has been recorded on citrus, mango, cashew, papaya, guava, pepper, and several wild host plants (Hanna 2005). *Bactrocera caryeae* has been recorded on mango, citrus and guava, while *B. zonata* has been recorded on a wide range of hosts (White and Elson-Harris 1992).

Suitability of the environment

- The survival of these fruit flies in a wide range of climates suggests that regions of Australia are likely to be suitable for the establishment of these species (Espenshade 1990; Gomes 2000; Hanna 2005). *Bactrocera* species occur throughout the Indian subcontinent (White and Elson-Harris 1992), across climatic zones that are similar to areas in Australia (Espenshade 1990).
- *Bactrocera caryeae* is distributed in the tropical climatic zone of southern India, and is active at higher altitudes (Allwood and Drew 1997). *Bactrocera zonata* is a tropical species endemic to India (Drew and Raghu 2002). Each has the potential to establish itself in similar environments in Australia.
- Originally considered to be an exclusively tropical fruit fly, the establishment of *B. zonata* in Egypt in 2001 demonstrates that *B. zonata* can also thrive in a Mediterranean climate (Duyck *et al.* 2004). The *B. zonata* population in Egypt has demonstrated adaptation in a relatively short time frame (Iwahashi and Routhier 2001), proving its ability to establish and successfully compete in new environments.
- *Bactrocera invadens* has expanded its distribution from the Indian-subcontinent to tropical Africa (Hanna 2005).

Cultural practices and control measures

- As these fruit flies are internal pests of fruit, current insecticide spray regimes may not have any impact on their establishment in Australia.
- Integrated pest management programs have been adopted for other fruit flies, including monitoring the emergence and dispersal of adults, using baits, male annihilation and sterile insect techniques (Kuba *et al.* 1996; CAB International 2007).
- Trapping systems are routinely used in commercial orchards to detect fruit flies (Dominiak 2007). Currently, trapping measures are used in Australia implemented to effectively detect *Bactrocera* species in Australia.

The reproductive strategy and survival of the pest

- Adults of *Bactrocera* species typically live for several months depending on the species and temperature, for example *B. dorsalis* can live up to 12 months in cool conditions (Christenson and Foote 1960; Gomes 2000; Dhillon *et al.* 2005).
- *Bactrocera* species prefer warm, humid weather and abundance increases as mangoes ripen but the population declines during dry periods (Peña *et al.* 1998).
- For most *Bactrocera* species, it is the adults that are best able to survive low temperatures, with a nominal torpor threshold of 7°C, dropping as low as 2°C in winter (OEPP/EPPO 2005). *Bactrocera zonata* overwinters in the larval or pupal stage (Gomes 2000; OEPP/EPPO 2005) and mating begins after the adults emerge, when the ambient temperature increases.
- The average life span of the adult in the field will normally depend on the existence and presence of natural enemies, on the nature and abundance of available food and on climatic conditions (Gomes 2000).
- The wide host ranges allow these fruit flies to breed actively in the field from the end of winter through to autumn and produce several generations per year. The life cycle is completed in 20 days under optimum conditions but is prolonged by cool temperatures (Gomes 2000).

Their wide host ranges, short generation times and the suitability of the environment support an establishment rating of 'high'.

4.4.3. Probability of spread

The likelihood that fruit flies will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **HIGH**.

The suitability of the natural or managed environment for natural spread

- These fruit flies have been reported from a variety of environments. For example *Bactrocera correcta* and *B. zonata* are widespread in the tropics (Gomes 2000; Weems 2001) and *B. zonata* has recently established in the Mediterranean climate of Egypt (Duyck *et al.* 2004). *Bactrocera invadens* has established in humid lowland regions of Africa (Hanna 2005). There are similarities in the natural and managed environments of these regions with many of those in Australia.
- These species have a broad host range (Allwood *et al.* 1999), and the hosts are readily available in Australia.
- The incursion of *B. papayae* in northern Australia in 1995 demonstrates the ability of introduced fruit fly species to spread. The fruit fly was detected near Cairns and the infested area was found to extend from Kennedy in the south to as far north as Cooktown, with the largest infestations around Mareeba and Cairns. The declared pest quarantine area included 78,000 km^2 of north Queensland, including urban areas, farms, riparian habitats, coastline and a large part of the Wet Tropics World Heritage Area before it was finally declared eradicated in 1999 (Cantrell *et al.* 2002). *Bactrocera correcta* and *B. zonata* would have a similar capacity to spread in Australia.

Presence of natural barriers

- The presence of natural barriers such as deserts or mountain ranges may inhibit long-range natural spread of these fruit flies. The long distances between commercial host crops in Australia may reduce the potential for long-range natural spread of fruit flies.
- *Bactrocera* species adults engage in extensive dispersive movements during the early adult phase prior to host-seeking and mating, and mature flies leave locations where hosts are dwindling in search of new hosts. During these periods, some individuals may move large distances in a few weeks. A dispersal distance of 25 km has been recorded for *B. zonata* (Gomes 2000). Should these fruit flies be introduced to major commercial production areas of Australia they are capable of short distance spread unaided.
- *Bactrocera zonata* tends to remain in one area when adequate food and hosts are available (Gomes 2000).

Potential for movement with commodities or conveyances

- The major means of dispersal to previously unaffected areas is transport of infested fruits (Baker *et al.* 2000). Adults and immature forms may spread undetected by this means.
- There are restrictions in place in Australia on the movement of fruit to prevent the spread of fruit flies, including Mediterranean fruit fly, Queensland fruit fly and exotic species.
- Following the incursion of *B. papayae* in northern Australia in 1995, fruit fly traps for exotic *Bactrocera* species are now located in Australia at each first port of call to attract and trap these fruit flies. These traps may limit the spread of these species by providing early warning of their presence that would lead to their successful eradication, as occurred with *B. philippinensis* in Darwin in 1999.

Their broad host-ranges, their ability to tolerate cold temperatures, their natural dispersal ability (strong flier) and their movement with commodities support a spread rating of 'high'.

4.4.4 Overall probability of entry, establishment and spread

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

The overall probability that fruit flies will be imported as a result of trade in mango fruit from India, be distributed in a viable state to a susceptible host, establish and spread within Australia, is: **HIGH**.

4.4.5 Consequences

The consequences of the entry, establishment and spread of fruit flies in Australia have been estimated according to the methods described in Table 2.3. The assessment of potential consequences is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**Impact score**: E – Significant at the regional level. • *Bactrocera caryeae* has a narrow host range of which most are tropical fruits (Allwood *et al.* 1999). • *Bactrocera correcta* has a wide host range (Allwood *et al*. 1999) and has the potential to become a pest of citrus and peach as well as several other subtropical fruits (Weems 1987). • *Bactrocera invadens* is considered highly invasive and is known to infest a range of edible and wild fruit hosts (Drew *et al*. 2005). • *Bactrocera zonata* is a polyphagous species attacking some 40 species of fruit and vegetables and has also been recorded from wild host plants of the families Euphorbiaceae, Lecythidaceae and Rhamnaceae (Duyck *et al.* 2004).
Other aspects of the environment	**Impact score**: C – Significant at the local level. Fruit flies introduced into a new environment may compete for resources with native species.
Indirect	
Eradication, control etc.	**Impact score**: F – Significant at the national level. • A control program would add considerably to the cost of production of the host fruit, costing between $A200-900 per ha depending on the variety of fruit produced and the time of harvest (HPC 1991). • In 1995, the *B. papayae* (papaya fruit fly) eradication program using male annihilation and protein bait spraying cost $A35 million (SPC 2002). • Recent research has highlighted the potential prevalence of insecticide resistance in *Bactrocera* species (Hsu *et al.* 2006; Skouras *et al*. 2007). Incursion of insecticide resistant populations of *Bactrocera* species would be more difficult to control or eradicate and add significantly to the costs of these programs.
Domestic trade	**Impact score**: E – Significant at the regional level. The presence of these fruit flies in commercial production areas may result in interstate trade restrictions on a wide range of commodities.

International trade	**Impact score**: E – Significant at the regional level. These fruit flies are regarded as major destructive pests of horticultural crops in various parts of the world. Although they can cause considerable yield losses in orchards and urban backyards, they also have consequences for Australian horticultural industries on gaining and maintaining export markets. • Due to the papaya fruit fly outbreak which occurred in north Queensland, Australia experienced trade restrictions that affected the whole country. In the first two months of the papaya fruit fly eradication campaign, about $A600,000 worth of exports were interrupted (Cantrell *et al.* 2002). • Within a week of the papaya fruit fly outbreak being declared, Japan ceased imports of mangoes at a cost of about $A570,000; New Zealand interrupted its $A30,000 banana trade and the Solomon Islands completely stopped importing fruit and vegetables from Queensland (Cantrell *et al.* 2002) until eradication was declared.
Environmental and non-commercial	**Impact score**: D – Significant at the district level. Broad-scale chemical control of fruit flies would have significant effects on fragile rainforest ecosystems (Cantrell *et al.* 2002).

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

4.4.6. Unrestricted risk estimate

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

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

As indicated, the unrestricted risk for fruit flies has been assessed as 'high', which is above Australia's ALOP. Therefore, specific risk management measures are required for this pest.

4.5. Fruit flies [Diptera: Tephritidae] – mangoes as a non–preferred host

4.5.1. Previous policy: Melon fruit fly – *Bactrocera cucurbitae* [Diptera: Tephritidae]

Melon fruit fly (*Bactrocera cucurbitae*) is a very serious pest of cucurbit crops and has been recorded from a few non-cucurbit hosts (White and Elson-Harris 1992). White and Elson-Harris (1992) note that many of the non-cucurbit host records may have been based on casual observation of adults resting on plants or caught in traps set in non-host trees.

Melon fruit fly has previously been assessed for the importation of mango from Taiwan with an unrestricted risk rating of 'low'**.** The existing policy for Melon fruit fly is adopted for the importation of mango from India as the risks of importation and distribution are judged to be similar. Therefore, melon fruit fly is not considered further in this policy.

4.5.2. Previous policy: Pumpkin fruit fly – *Bactrocera tau* [Diptera: Tephritidae]

Pumpkin fruit fly (*Bactrocera tau*) shows a preference for attacking the fruits of cucurbit crops, but has also been reared from the fruits of a number of non-cucurbit hosts (White and Elson-Harris 1992). Mango is not listed as a host of Pumpkin fruit fly by Allwood *et al*. (1999).

Pumpkin fruit fly has previously been assessed for the importation of mango from Taiwan with an unrestricted risk rating of 'very low'. The existing policy for Pumpkin fruit fly is adopted for the importation of mango from India as the risks of importation and distribution are judged to be similar. Therefore, Pumpkin fruit fly is not considered further in this policy.

4.6. Armoured scales [Hemiptera: Diaspididae]

Armoured scales construct a wax-like, fibrous 'scale' that covers the insect (Carver *et al.* 1991). This 'scale' forms a protective barrier against physical and chemical attack (Foldi 1990), and strongly affixes the insect to the plants on which they occur (Burger and Ulenberg 1990). Scale insects are primarily sedentary, small and often inconspicuous and occur widely on plants and plant products. Armoured scales are unlikely to be killed by any washing solution, even if insecticidal, as the physical properties of their protective covers provide an effective barrier against contact toxicants (Foldi 1990).

The crawlers wander around finding a suitable place to settle. Once settled, they secrete a scale cover by producing waxy filaments that are laid down in a circular fashion by rotation of the body. The male scale is smaller and more oblong than the female and at the final moult produces a tiny winged male that slips out from beneath the scale and flies off to find a female that needs mating.

The armoured scales of quarantine concern associated with mango fruit are:

- *Abgrallaspis cyanophylli* – Cyanophyllum scale**[EP]**
- *Parlatoria crypta* – mango white scale

Abgrallaspis cyanophylli has previously been assessed for the importation of mangoes from Taiwan with an unrestricted risk rating of 'very low'**.** The existing policy is adopted for this scale, as the risks of importation and distribution are judged to be similar. Therefore, Cyanophyllum scale is not considered further in this policy.

4.6.1. Probability of entry

Probability of importation

The likelihood that mango white scale will arrive in Australia with the importation of mango fruit from India is: **HIGH.**

Association of the pest with the pathway at its origin

- Mango white scale has been reported in India on mangoes (Ben-Dov *et al.* 2006).
- Armoured scales are quite small and may be difficult to detect, particularly in low numbers. Female adults of mango white scale are approximately 1.25 mm long and 1 mm wide (Ben-Dov *et al.* 2006).
- First instar nymphs (or crawlers) are capable of movement onto fruit where they permanently attach and commence feeding (Beardsley and Gonzalez 1975). Subsequent instars are sessile (Watson 2007). The normal post-harvest practice of washing fruit to remove sap (Morton 1987) may remove some mango white scale on the fruit at the time of harvest, but the effective removal of all scales may be difficult (Taverner and Bailey 1995).
- The detection of mango white scale on Pakistani mangoes on arrival in the United Kingdom (DEFRA 2008) demonstrates that post-harvest cleaning and washing will not remove all scales and quality control inspectors within the packing house may miss some infested fruit.

Ability of the pest to survive transport and storage

- As the development of armoured scales is strongly dependant on temperature (Beardsley and Gonzalez 1975), the development of nymphs would be slowed or halted by cool storage. However attached adults and nymphs can remain viable during transport and storage as the fruit would provide an ample supply of food during transit.

Ability of the pest to survive existing pest management procedures

- Armoured scale species can be controlled with the use of insecticides that hinder the normal formation of the protective scale cover (Foldi 1990).
- Crawlers are mobile, with the ability to disperse and settle on twigs, leaves, fruit and the bark of tree trunks (Timmer and Duncan 1999). Once settled, the crawlers penetrate the plant with their piercing stylets and feed on the juices. Females become sessile for the remaining nymphal instars (Carver *et al.* 1991). It is likely that fruit sent to be packed for export will contain some of these pests, as field control does not provide complete control of scales (Taverner and Bailey 1995).
- Mango white scale has been intercepted on mango fruit, showing that armoured scales can survive existing pest management procedures.

The inconspicuous nature of adult mango white scale, its resistance to standard washing procedures, and its history of interception on mango fruit supports a probability of importation rating of 'high'.

Probability of distribution

The likelihood that mango white scale will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of mango fruit from India, is: **LOW**.

Ability of the pest to move from the pathway to a suitable host

- The stages associated with imported fruit would be immature forms or adults. However, during developmental stages scale insects are firmly attached to their host and are usually incapable of independent movement (Carver *et al*. 1991).
- Either mated female scales would need to arrive in Australia with mango fruit, or male scales would need to complete development, emerge and locate a female for mating, before eggs could be laid.
- There are two principal means by which armoured scales may transfer to a suitable host: active dispersal of crawlers and the action of wind (Beardsley and Gonzalez 1975). Birds, insects and other animals, including humans, may also act as vectors.
- Emerging crawlers (first instars) would need to locate a suitable host to infest. While crawlers are capable of independent movement, and can be moved by wind (Carver *et al.* 1991), they generally move for a limited period of time and do not move far before settling to feed (Ker and Walker 1990). Abiotic factors such as unsuitable temperatures strongly influence the survival rate for crawlers during the dispersal stage (Watson 2007).
- Although, crawlers may travel up to 150 m, they usually settle within several dozen centimetres of their hatching site (Koteja 1990).
- Mango white scale has a wide host range (Ben-Dov *et al.* 2006). Thus there is a good chance of a suitable host being available in Australia.

Distribution of the imported commodity in the PRA area

- Mangoes would be distributed for sale to multiple destinations in Australia.
- Wholesalers, retailers or consumers could discard infested fruit at multiple locations. Mango will presumably be shipped all over Australia, so a portion of the pests that enter the country are likely to reach areas of host abundance.

Risks from by-products and waste

- The intended use of the commodity is human consumption, but waste material will be generated. Immature stages could complete development on discarded waste.

- The nymphal stages associated with imported fruit waste may develop into adults. However, adult female scales are firmly attached to their host and are usually incapable of independent movement (Carver *et al.* 1991).
- The principal dispersive stage of scale insects is the first instar crawlers (Carver *et al.* 1991). Adult males, while capable of independent flight are incapable of laying eggs and thus would not be able to move the scale infestation onto a new host.

The natural dispersal mechanism that allows for the movement of scale species from discarded fruit waste to a suitable host is a significant limiting factor as armoured scales are primarily sessile. Scales have a limited ability to disperse independently from the mango fruit pathway. Therefore a rating of 'low' is allocated.

Probability of entry (importation x distribution)

The overall probability of entry for mango white scale is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for armoured scales is estimated to be: **LOW**.

4.6.2. Probability of establishment

The likelihood that mango white scale will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **HIGH**.

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- *Parlatoria crypta* is capable of surviving and reproducing on a wide potential host range (Ben-Dov *et al.* 2006). Host species include horticultural crops and ornamentals that are widespread in cities, towns and horticultural production areas in Australia.
- Armoured scales can be highly polyphagous (Beardsley and Gonzalez 1975), with many potential host species present in Australia.

Suitability of the environment

- Armoured scales are distributed in a wide range of climates (Ben-Dov *et al.* 2006; Watson 2007), and regions of Australia are likely to be suitable for the establishment of these species (Espenshade 1990).
- Climatic conditions, particularly temperature, humidity and rainfall strongly influence the development of armoured scales (Beardsley and Gonzalez 1975). Temperature influences both the initiation and rate of crawling, as well as crawler survival. The threshold for crawler activity appears to be between 13°C and 20°C (Beardsley and Gonzalez 1975). Therefore most of Australia would be suitable. Low humidity and extreme temperatures limit the establishment and spread of *Diaspididae* species (Beardsley and Gonzalez 1975).

Cultural practices and control measures

- Scales are external feeders and existing pest management practices such as pesticide application may impact the establishment of scales in Australia. Scales are often controlled by predators such as small parasitic wasps and beetles (Dreistadt *et al.* 1994).
- Chemical controls in commercial orchards may impact on the establishment of these scales, but would not be applied in all the environments where these scales could establish, particularly in urban environments. Broad spectrum insecticides applied to control scales and other arthropods may also reduce population numbers of natural enemies of armoured scales (Dreistadt *et al.* 1994).

The reproductive strategy and survival of the pest

- Reproduction in *Diaspididae* species is bisexual (Beardsley and Gonzalez 1975), so a mating pair is not needed.
- No specific information is available on the biology of mango white scale, but related species have many generations per year and produce high numbers of offspring. For instance, *P. pergandii* populations in Queensland, Australia, produce five to six generations per year (Smith *et al.* 1997).
- The survival of *Diaspididae* species is strongly influenced by relative humidity and temperature (Beardsley and Gonzalez 1975). They cannot survive well under low relative humidity and high temperatures. Several species of *Parlatoria* are already established in Australia, suggesting that mango white scale may also be able to establish.
- Adult males are short-lived, winged and capable of weak flight. They lack functional mouthparts and cannot feed. This stage generally lives for only a few hours (Beardsley and Gonzales 1975).

The suitability of the environment, the availability of numerous host species, the high reproductive rate and the adaptability of these species supports an establishment rating of 'high'.

4.6.3. Probability of spread

The likelihood that mango white scale will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **MODERATE**.

The suitability of the natural or managed environment for natural spread

- *Parlatoria* species have been reported from a variety of environments. For example mango white scale is present in parts of Asia and Africa (Ben-Dov *et al.* 2006). There are similarities in the natural and built environments of these areas with those in Australia.
- Mango white scale has a broad host range (Ben-Dov *et al.* 2006) and many of these hosts occur in Australia.
- The spread of *Parlatoria* species depends on relative humidity and temperature (Beardsley and Gonzalez 1975). The number of days for each developmental stage and the number of generations per year depend on temperature, humidity and rainfall (Beardsley and Gonzalez 1975). They cannot spread and establish well under low relative humidity and high temperatures.

Presence of natural barriers

- The presence of natural geographical barriers such as deserts or mountain ranges will prevent long-range natural spread of these armoured scales.
- Crawlers are the primary dispersal stage and move to new areas of the plant or are dispersed locally by wind or animal contact. Mortality due to abiotic factors is high in this stage (Beardsley and Gonzales 1975). Dispersal (particularly long distance dispersal) of sessile adults and eggs occurs almost entirely through human transport of infested plant material.
- If mango white scale is introduced to major commercial production areas of Australia the monoculture will favour slow natural local spread.

Potential for movement with commodities or conveyances

- Movement of infested planting material or produce is the main way by which armoured scales have been introduced to other countries (Beardsley and Gonzalez 1975).
- Adults and nymphs may be spread through agricultural practices (Dreistadt *et al.* 1994), including movement of plant material, equipment, and personnel within and between orchards or other commercial production sites.
- The most common mode of dispersal of sessile stages is on plant parts transported by human activities (Beardsley and Gonzalez 1975; Watson 2007). In particular, long-range dispersal of the sessile female scale can only occur by transport of infested plant material. Passing animals or people can also vector crawlers over great distances (Beardsley and Gonzalez 1975; Watson 2007).
- Short-range dispersal may occur through the movement of crawlers in wind currents or by biological or mechanical vectors (Willard 1974).

Potential natural enemies

- Several natural enemies that attack scales occur in Australia. *Aphytis* wasps parasitise the eggs, nymphs and adults of *Parlatoria* species and the chilocorus ladybird (*Chilocorus circumdatus*) is a common predator of armoured scales (Smith *et al.* 1997). The wide distribution of some *Parlatoria* species in Australia suggests that these parasites are unlikely to be effective in preventing establishment and spread of mango white scale.

Armoured scales have a limited ability to disperse unaided. Crawlers are the primary dispersal stage, but mortality due to abiotic factors is high in this stage (Beardsley and Gonzales 1975). Subsequent instars are sessile (Watson 2007) and dispersal of sessile adult females and eggs occurs almost entirely through human transport of infested plant material. Therefore a spread rating of 'moderate' is allocated.

4.6.4. Overall probability of entry, establishment and spread

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

The overall probability that mango white scale will be imported as a result of trade in mango fruit from India, be distributed in a viable state to a susceptible host, establish and spread within Australia, is: **LOW**.

4.6.5. Consequences

The consequences of the entry, establishment and spread of mango white scale have been estimated according to the methods described in Table 2.3. The assessment of potential consequences is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D** – Significant at the district level. Armoured scales can cause significant impacts to mangoes at the district level: • These pests are commonly polyphagous (Beardsley and Gonzalez 1975) and host plants are common in Australia (e.g. mango and citrus) (Ben-Dov *et al.* 2006). • Fruits are disfigured by the appearance of the scales, and toxins in their saliva cause depressions, discolorations and other distortions of the host tissues (Beardsley and Gonzalez 1975; Kosztarab 1990). • Defoliation, splitting of bark, twig dieback and an overall decline in host plant health, sometimes leading to death, may follow if the infestation is heavy (Beardsley and Gonzalez 1975; Smith *et al.* 1997).
Other aspects of the environment	**B** – Minor significance at the local level. There are no known direct consequences of armoured scales on other aspects of the environment. When introduced into a new environment they will compete for resources with the native species.
Indirect	
Eradication, control etc.	**D** – Significant at the district level. Armoured scales are estimated to have consequences that are significant at the district level: • Programs to minimize the impact of these pests on host plants are likely to be costly and include pesticide applications and crop monitoring. • Existing control programs (e.g. broad spectrum pesticide applications) may be effective to control armoured scales on some hosts, but may not be effective on hosts where targeted pest management programs are used.
Domestic trade	**C** – Significant at the local level. The presence of armoured scales in commercial production areas is likely to have a significant effect at the local level due to interstate trade restrictions on a wide range of commodities. These restrictions may lead to a loss of markets and industry adjustment.
International trade	**D** – Significant at the district level. The presence of armoured scales in commercial production areas of various export commodities (e.g. mango, citrus) is likely to have a significant effect, due to limitations on access to overseas markets where these pests are absent. For example, *P. crypta* is a pest of quarantine concern to the USA.
Environmental and non-commercial	**B** – Minor significance at the local level. Although insecticide applications would be required to control these pests on susceptible crops, this is considered to be of minor significance at the local level.

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**.

4.6.6. 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 mango white scale	
Overall probability of entry, establishment and spread	**Low**
Consequences	**Low**
Unrestricted risk	**Very low**

As indicated, the unrestricted risk for armoured scales has been assessed as 'very low', which meets Australia's ALOP. Therefore, specific risk management measures are not required for this pest.

4.7. Mealybugs [Hemiptera: Pseudococcidae]

Mealybugs are small, oval, soft-bodied, slow moving insects covered with white powdery wax (Furness and Charles 1994). They are sucking insects that injure plants by extracting large quantities of sap. They also produce honeydew, which serves as food for ants or as a substrate for the development of sooty mould. Mealybugs generally prefer warm, humid and sheltered sites away from adverse environmental conditions and natural enemies. Many mealybug species pose serious problems for agriculture, particularly when introduced into new areas of the world where their natural enemies are not present (Miller *et al.* 2002).

Mealybugs impact on plants and commodities by:

- sucking plant sap through their tubular stylets. If left unchecked, heavy infestations of mealybugs may damage or weaken plants, directly causing premature leaf drop, dieback and even plant death.
- causing indirect damage by injecting toxins or plant pathogens into host plants (such as grapevine leaf roll virus (Pfeiffer and Schultz 1986), mealybug pineapple wilt).
- contaminating fruit with egg sacs, nymphs and adults (UC ANR 2006), or by depositing a waste product, 'honeydew', on the leaves and fruit. Honeydew may act as a substrate for sooty mould to grow. Sooty mould may reduce photosynthesis and downgrades fruit quality.

Mealybugs develop from an egg and through a number of nymphal (immature instar) stages before undergoing a final moult into the adult form. In some species, the late instars may be non-feeding. After moulting, the male mealybug emerges as a tiny winged form, while the adult female mealybug is oval in shape and up to about 4 mm long. Adult females and nymphs are covered in a white waxy substance that is moisture repellent and protects them against desiccation. Reproduction in mealybugs is sexual or parthenogenetic and there may be multiple generations per year.

The mealybugs of quarantine concern associated with mango fruit are:

- *Planococcus lilacinus* – coffee mealybug [EP]
- *Rastrococcus iceryoides* – downy snowline mealybug
- *Rastrococcus invadens* – mango mealybug
- *Rastrococcus spinosus* – Philippine mango mealybug [EP]

The assessment also includes the following species which are quarantine pests for Western Australia:

- *Ferrisia malvastra* – Malvastrum mealybug
- *Ferrisia virgata* – striped mealybug

In the past, *F. malvastra* has commonly been confused with *F. virgata*. Both species are morphologically similar (Gullan *et al.* 2003). The most significant difference is that *F. virgata* reproduces bisexually, whereas *F. malvastra* reproduces parthenogenetically. As a result, records of host species and economic damage before 1980 for *F. virgata* may be referring to *F. malvastra* (Ben-Dov *et al*. 2006).

Planococcus lilacinus and *R. spinosus* have previously been assessed with the importation of mangoes from Taiwan with an unrestricted risk rating of 'low**'.** The existing policy for these mealybugs is adopted for the importation of mango from India as the risks of importation and distribution are judged to be similar. Therefore, these mealybugs are not considered further in this policy.

Ferrisia malvastra, F. virgata, Rastrococcus iceryoides, and *R. invadens* have been grouped together because of similar biology and ecology (Williams 1989).

The discussion below largely concentrates on *R. invadens* as an example of the mealybugs of concern. However, the conclusions reached are valid for all species being assessed.

4.7.1. Probability of entry

Probability of importation

The likelihood that mealybugs will arrive in Australia with the importation of mango fruit from India is: **HIGH**.

Association of the pest with the pathway at its origin

- These mealybugs have been reported in India on mango (Ben-Dov *et al.* 2006) affecting leaves, blossoms and fruit (Peña and Mohyuddin 1997; Tobih *et al.* 2002; Peña 2004; Moore 2004).
- Later instar nymphs and adult females of *R. iceryoides* usually feed on the tender terminal shoots, inflorescences and fruits, whereas first instar nymphs feed on the undersides of leaves. In severe infestations, all the tender shoots, inflorescences and fruits of mango are infested by different stages of the pest (Rawat and Jakhmola 1970).
- Mangoes packed for export typically consist of the fruit and a very short (approximately 0.3 to 0.5 cm) pedicel attached to the top of the fruit. The morphology of the fruit does not provide any hiding places for the mealybugs. Despite this, mealybugs have been found in mango consignments entering the USA (USDA 2006), proving that they are associated with the fruit pathway.
- Mealybugs are quite small and may be difficult to detect, particularly in low numbers. The common length for adult female mealybugs of most species is approximately 1.5–4 mm long (Akintola and Ande 2006).
- Mealybug infestations may promote the growth of sooty mould on the surface of the fruit. Fruit with sooty mould may be rejected at the point of harvest but symptoms would need to be severe for rejection to occur at this point.
- The normal post-harvest practice of washing fruit to remove sap (Morton 1987) may remove some mealybug species on the fruit at the time of harvest, but the effective removal of all mealybugs may be difficult (Taverner and Bailey 1995).
- However, the detection of mealybugs on arrival of mangoes in the USA (USDA 2006) demonstrates that post-harvest cleaning and washing will not remove all mealybugs and quality control inspectors within the packing house are likely to miss some infested fruit.

Ability of the pest to survive transport and storage

- Mealybugs are likely to survive storage and transportation, as shown by the interception of mealybugs on mangoes imported into the USA (USDA 2006).
- Adult females of *R. invadens* live from 51–110 days; nymphal development is about 28–30 days for both male and female mealybugs (Moore 2004). Mated adult females of *R. iceryoides* can live for 13–23 days and unmated females can live for up to 80 days, whereas adult males live for only 1–2 days (Rawat and Jakhmola 1970). There is a high probability that viable female mealybugs present on the fruit at point of export would still be viable on arrival in Australia.

- The optimum temperature for storage of mangoes is approximately 13-14°C, as storage below this temperature results in chilling injury to the fruit (Lederman *et al.* 1997; Nair and Singh 2004). Adult female *R. iceryoides* are known to hibernate overwinter in India (Rawat and Jakhmola 1970). The development of nymphs and other pre-adult stages would be slowed or halted by cool storage.

Ability of the pest to survive existing pest management procedures

- There are both chemical and biological options for mealybug control. Mealybugs have been detected on imported mango fruit in the USA (USDA 2006), showing that they can survive some existing pest management procedures.

The high fecundity, small size, and ability to survive packing and sorting washes and inspections supports an assessment of 'high' for the importation of these species.

Probability of distribution

The likelihood that mealybugs will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of mango fruit from India is: **MODERATE**.

Ability of the pest to move from the pathway to a suitable host

- A range of plants, widely distributed, abundant, native and/or cultivated in Australia, including *Acacia, Citrus*, *Malus, Mangifera, Musa* and *Vitis*, can act as hosts for these pests (Ben-Dov *et al.* 2006).
- Juvenile mealybugs are able to move about within the host tree, and can be dispersed by wind, visiting insects and birds, and on clothing (Hely *et al.* 1982).
- Long range dispersal of mealybugs can also occur by the movement of adults and nymphs with fresh vegetative material.
- Crawlers are small and less robust than adult females, but they can be dispersed onto other plants up to several hundred metres by wind (Rohrbach *et al.* 1988). Adult females are wingless and need to be carried onto hosts by wind or vectors such as other insects or people.

Distribution of the imported commodity in the PRA area

- Mangoes would be distributed for sale to multiple destinations in Australia.
- Mealybugs would need to survive transportation and storage. Although cold storage may impact the survival of mealybugs, some mealybugs are likely to survive storage and distribution as temperatures employed are commonly approximately 13-14°C (Lederman et al. 1997; Nair and Singh 2004).
- Mango will presumably be shipped all over Australia, so a portion of the pests that enter the country are likely to reach areas of host abundance.

Risks from by-products and waste

- The intended use of the commodity is human consumption but waste material will be generated (e.g. skins of fruit, overripe fruit, blemished or damaged fruits). Immature stages may complete development on discarded waste.
- While mealybugs have limited mobility, adult females and juveniles are able to crawl between host plants in infested areas (Meyerdirk *et al.* 2001) and so could migrate from waste fruit to any adjacent vegetation.
- Adult males of *R. invadens* are winged, fragile and do not live for more than several days. They detect females through pheromones and are able to fly to them in order to mate (Grimes and Cone 1985). *Rastrococcus iceryoides* males are also winged but fragile and do not live for more than 1–2 days (Rawat and Jakhmola 1970; Grimes and Cone 1985).

While the ability of mealybugs to self-disperse is limited, this is offset by the capacity of mealybugs to produce large numbers of offspring and by other means of dispersal, including transport of commodities. Therefore, a risk rating of 'moderate' for dispersal is allocated.

Probability of entry (importation x distribution)

The overall probability of entry for mealybugs is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for mealybugs is estimated to be: **MODERATE**.

4.7.2. Probability of establishment

The likelihood that mealybugs will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **HIGH.**

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- These mealybugs are capable of surviving and reproducing on a wide host range (Agounke *et al.* 1988; Ivbijaro *et al.* 1992; Ben-Dov *et al.* 2006). Host species of these mealybugs are widespread in cities, towns and horticultural production areas throughout Australia.
- *Rastrococcus invadens* is highly polyphagous, infesting about 45 species in 22 families (Agounke *et al.* 1988) including fruit trees, shade and ornamentals, cereal and tubers (Ivbijaro *et al.* 1992).
- In Pakistan, *R. spinosus* is considered an important pest of mangoes and has also been recorded on oleander, banana, guava, orange and other plants (Mahmood *et al.* 1980).

Suitability of the environment

- These mealybugs are distributed in a range of geographic regions (Williams 2004, Ben-Dov *et al.* 2006), some of which are climatically similar to parts of Australia.
- Many mealybugs are considered invasive and have become established after introduction to new environments. For example, *Planococcus lilacinus* is native to the Afrotropical region (Miller *et al.* 2002) and now has a wider distribution, excluding Australia (Ben-Dov 1994). *Rastrococcus invadens* is of South-East Asian origin, but is now established in western Africa. The mango mealybug was accidentally introduced into western Africa in the early 1980s and became a major pest of various ornamental and fruit trees (Agounke *et al.* 1988; Boavida *et al.* 1995).
- Six species of *Rastrococcus* are reported in Australia, demonstrating the suitability of climatic conditions for at least some species of this genus (Ben-Dov *et al.* 2006).
- Climatic factors and identity of the host plant influence a number of aspects of the life history of *R. invadens* (Moore 2004). The number of days for each developmental stage is influenced by both host plant and temperature (Moore 2004). The population density of *R. invadens* decreases during rainy seasons and peaks during the dry season (Boavida and Neuenschwander 1995).

The reproductive strategy and survival of the pest

The successful reproductive strategy of these pests relies on the longevity and egg-laying ability of the adult female, the mobility of the short-lived adult male, the ability of the crawlers to disperse via crawling, vectors or wind, and their ability to locate new hosts.

- Mealybug species reproduce either sexually or parthenogenetically (Grime and Cone 1985). For mealybugs that reproduce sexually, male mealybugs must locate a female for a population to establish. Male mealybugs are small, non-feeding insects with a short life

span, usually just a few days. Adult males are winged but are weak flyers (Grimes and Cone 1985). Female mealybugs release a pheromone to attract males for mating (Grimes and Cone 1985).
- *Rastrococcus iceryoides* is known to reproduce sexually, and mating must occur if viable eggs are to be produced (Rawat and Jakhmola 1970). On mango, fertility of *R. iceryoides* has been found to range from 450–585 eggs per female (Rawat and Jakhmola 1970).
- Unmated females of *R. iceryoides* live for up to 80 days whereas mated females live for 13–23 days. Adult males live for only 1–2 days and start copulating soon after they emerge (Rawat and Jakhmola 1970).
- Development time of *R. invadens* is influenced by the host plant. Experiments on mango, figs, frangipani and citrus showed that mango-fed nymphs had the highest survival and shortest development rate while the development time of citrus-fed nymphs was the longest (Moore 2004).
- *Rastrococcus invadens* is capable of producing eight generations a year in India (Moore 2004). The entire life cycle of *R. invadens* can be completed in 31-84 days (Peña *et al.* 1998).

Cultural practices and control measures

- Controls in place for other pests of economic concern may reduce the likelihood of establishment of mealybugs in agricultural ecosystems. However, many hosts available in Australia are present in urban and suburban areas as well as in unmanaged environments. Therefore, it is likely that there would be little overall barrier to the establishment of these mealybugs in Australia.

The suitability of the environment, availability of hosts, high reproductive rate and adaptability, all support an establishment rating of 'high' for these species.

4.7.3. Probability of spread

The likelihood that mealybugs will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **HIGH**.

The suitability of the natural or managed environment for natural spread

- These mealybugs have been reported from a number of environments. For example *Rastrococcus invadens* is widespread throughout the tropics and subtropics (Ben-Dov *et al.* 2006). There are similar environments in Australia.

Presence of natural barriers

- *Rastrococcus invadens* is capable of producing eight generations per year in India (Moore 2004). After second and subsequent generations of mealybugs have become established on commercial, household and wild host plants, mealybugs are likely to persist and to spread progressively over time. This spread would be assisted by wind dispersal, vectors and the movement of plant material.
- Due to the limited distance mealybugs can move by crawling or wind dispersal, natural barriers such as deserts, mountains or large areas where hosts are not present would limit the ability of these mealybug species to disperse between some areas.
- Mealybugs may be dispersed within and between orchards with the movement of personnel, infested plant material or by wind dispersal (Hely *et al.* 1982; Tobih *et al.* 2002).

- The crawler stage is the most active stage and is responsible for both active and passive dispersal. Crawlers can survive only a day without feeding and once they insert their style to feed they generally remain anchored permanently (CUES 2007). Selection of an appropriate feeding site is critical for subsequent development. Mortality is generally highest during the first instar and failure to settle is considered to be one of the major mortality factors for many species.

Potential for movement with commodities or conveyances

- Movement of infested planting material or produce has been reported as the probable way by which some mealybug species have been introduced to other countries (Tobih *et al.* 2002).
- Adults and nymphs are likely to be moved with plant commodities, as shown by the interception of mealybug species in the USA on imported mango fruit (USDA 2006).

Potential natural enemies

- Several natural enemies attack *R. invadens* including encyrtid parasitoids (*Anagyrus mangicola* and *Gyranusoides tebygi*) (Moore 2004; Tobih *et al.* 2002). These species are both endophagous parasitoids, specific to *R. invadens* (Boavida *et al.* 1995). They are not present in Australia.

Mealybugs have a limited ability to disperse independently. They may be spread passively by wind while at the crawler stage and have the ability to spread on imported plant material and commodities. Therefore a rating of 'high' for entry is allocated.

4.7.4. Overall probability of entry, establishment and spread

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

The overall probability that mealybugs will be imported as a result of trade in mango fruit from India, be distributed in a viable state to a susceptible host, establish and spread within Australia, is: **MODERATE**.

4.7.5. Consequences

The consequences of the entry, establishment and spread of mealybugs in Australia/Western Australia have been estimated according to the methods described in Table 2.3. The assessment of potential consequences is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D** – Significant at the district level. Mealybugs can cause direct harm to a wide range of plant hosts (Ben-Dov 1994). Fruit quality can be reduced by the presence of secondary sooty mould. • Mealybugs can cause considerable damage to host plants and crops. For example, mango mealybug and vine mealybug have caused major infestations and problems when introduced to West Africa and California respectively (Moore 2004; Haviland *et al.* 2005). • *Rastrococcus invadens* is reported to reduce the yield of mango crops by up to 90% in some parts of Africa (Moore 2004). • Mealybugs are highly polyphagous and host plants are common in Australia (e.g. citrus, mango, pineapple). Mealybugs are also known to transmit plant viruses such as grapevine leaf roll virus and cocoa swollen shoot virus (Williams 1996, Pfeiffer and Schultz 1986), and so can be an economic pest even at low densities.
Other aspects of the environment	**B** – Minor significance at the local level. There are no known direct consequences of this pest on other aspects of the environment. Mealybugs introduced into a new environment will compete for resources with native species.
Indirect	
Eradication, control etc.	**D** – Significant at the district level. Programs to minimise the impact of these pests on host plants are likely to be costly and include pesticide applications and crop monitoring. Existing control programs can be effective for some hosts (e.g. broad spectrum pesticide applications) but not all (e.g. where specific integrated pest management programs are used). • Because eggs of *R. invadens* diapause for up to six months in the soil, cultural control methods involving exposing and destroying the eggs are more effective than traditional chemical controls (Ishaq *et al.* 2004). • Biological control programs have been successful for some mealybugs; but these programs would involve introducing biological control agents in Australia. Costs for one successful African program are estimated at US $3.66 million (Bokon-Ganta *et al.* 2002).
Domestic trade	**C** – Significant at the local level. The presence of these pests in commercial production areas is likely to have significant effect at the local level because of any resulting trade restrictions on a wide range of commodities. These restrictions can lead to a loss of markets and industry adjustment.
International trade	**D** – Significant at the district level. The presence of these mealybugs in commercial production areas of a wide range of commodities (e.g. citrus, mango, pineapple, table grapes) could have a significant effect at the district level because of limitations of access to overseas markets where these pests are absent. For example *R. iceryoides* is a pest of quarantine concern to the United States (USDA 2006).
Environmental and non-commercial	**B** – Minor significance at the local level. Although additional insecticide applications would be required to control these pests on susceptible crops, this is not considered to have significant consequences for the environment.

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 considered to be: **LOW**.

4.7.6. Unrestricted risk estimate

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

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

As indicated, the unrestricted risk for mealybugs has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for mealybugs.

4.8. Cocoa tussock moth – *Orgyia postica* [Lepidoptera: Lymantriidae]

Cocoa tussock moth (*Orgyia postica*) is polyphagous (Fasih *et al.* 1989) and is an important defoliator of commercial crops including durian, eucalypts, longan, litchi, mango, mangosteen, poplar, rambutan, roses and table grapes (Nasu *et al.* 2004; CAB International 2007). Females are flightless and cling to the exterior of their cocoons and release pheromones to attract mates (Wakamura *et al.* 2005). Eggs hatch after about 5–6 days, and the resulting male larvae take 15–26 days to become fully grown and the larger, female larvae take 15–28 days (Sanchez and Laigo 1968). The female and male pupal stages last 4–5 and 6–7 days respectively (Sanchez and Laigo 1968). Temperature for egg hatch is 25°C for 5 days (Cheng *et al*. 2001), and for larval development, 25–30°C (Cheng *et al.* 2001). Adults live for about 5 days (Su 1985). The larvae also attack fruits, especially mango, rendering them unsuitable for sale (Fasih *et al.* 1989). In Taiwan it is a major pest of grapevines and roses (CAB International 2007). This species is related to the gypsy moth (*Lymantria dispar*) which is a major pest of forest trees in North America and Europe (NBII ISSG 2006).

4.8.1 Previous policy

Cocoa tussock moth has previously been assessed for the importation of mango from Taiwan with an unrestricted risk rating of 'negligible'. The existing policy for cocoa tussock moth is adopted for the importation of mango from India as the risks of importation and distribution are judged to be similar. Therefore, cocoa tussock moth is not considered further in this policy.

4.9. Red-banded mango caterpillar – *Deanolis sublimbalis* [Lepidoptera: Pyralidae]

The red-banded mango caterpillar is a serious pest of mangoes in India and South-East Asia (Gibb *et al*. 2007; Krull and Basedow 2006). This species is believed to have evolved with *Mangifera indica* in the India-Myanmar region (Waterhouse 1998), but is now reported from India eastwards to South-East Asia, southern China and Papua New Guinea (Waterhouse 1998). Since 1990 it has been detected on several Torres Strait Islands and is now known to occur at several locations on the far northern tip of Cape York Peninsula, Queensland, Australia and is now under official control (QDPIF 2005). As outlined in the pest categorisation table (*Appendix A.1*) this species is under official control in Queensland and a quarantine area has been established to restrict the movement of mango fruit and plant materials outside of this area. Larvae bore into both young and maturing fruits, feeding on the seed and fruit pulp (Krull and Basedow 2006). The species causes crop losses in the order of 10 – 15% in South-East Asia (QDPIF 2005).

The species examined in this pest risk analysis is:
- *Deanolis sublimbalis* – Red-banded mango caterpillar

4.9.1. Probability of entry

Probability of importation

The likelihood that red-banded mango caterpillar will arrive in Australia with the importation of mango fruit from India is: **MODERATE**.

Association of the pest with the pathway at its origin

- Red-banded mango caterpillar has been reported on mangoes in northern India (Peña and Mohyuddin 1997; Waterhouse 1998). Levels of infestation of 40 – 50% have been reported in the Philippines (Krull and Basedow 2006) and 20 – 40% fruit damage has been reported in Papua New Guinea (Tenakanai *et al*. 2006).
- Eggs are laid in small crevices (often dried anthracnose spots) on the peduncle, on non-fruiting vegetative branches close to fruit, or on the fruit itself (Krull and Basedow 2006). Eggs have been observed to be laid in clusters of 2 – 6 with 1 – 10 eggs per cluster (Sujatha and Zaheruddeen 2002), although Tenakanai *et al.* (2006) reported up to 15 eggs per cluster.
- Eggs are typically laid on fruit of marble size (Krull and Basedow 2006). Few eggs are observed on mature fruit (Krull and Basedow 2006).
- After 3 to 4 days, larvae hatch and burrow into the distal end of the mango fruit (Golez 1991). Larvae pass through 5 instars within the fruit, with a larval development period of 14 – 20 days (Golez 1991).
- Early instars feed on the fruit pulp forming a network of tunnels which may eventually cause the fruit to collapse (Golez 1991). Later instar larvae feed on the seed (Krull and Basedow 2006). Up to 11 larvae have been found in a single fruit, but they disperse in search of fresh fruit as the food source runs out (Tenakanai *et al*. 2006). Commonly, there is only a single larva in a fruit (Waterhouse 1998).
- Fruit infested at this young stage is misshapen and may abort (B. Pinese, personal communication 2008). Although red banded mango caterpillar feeds internally, the damage is conspicuous as sap oozing from entry holes stains the skin of the fruit

(Tenakanai *et al*. 2006). Frass may also be produced and deposited around the hole and infected fruits may split at the apex and develop longitudinal cracks (Krull 2004).

- Fruit infested with later instars has a conspicuous entry hole that leads to visible sap staining on the surface of the fruit (B. Pinese 2008, pers. comm.). Other symptoms include secondary fungal and bacterial infections of the fruit (Golez 1991).
- Infested fruit with obvious symptoms is likely to be graded out during harvesting and grading operations. However, late infested fruit with early instars may remain undetected.
- Larvae exit the fruit to pupate in deadwood, cracks or crevices in the bark of the host tree (Sujatha and Zaheruddeen 2002; Krull 2004; Krull and Basedow 2006; B. Pinese 2008, pers. comm.), or soil (Golez 1991).
- The larvae enter a pre-pupal stage lasting 2 – 3 days followed by a pupal period ranging from 9 – 14 days (Golez 1991). Total development (from egg to adult emergence) is completed in 28 – 41 days (Golez 1991).
- Pupation in fruit was not observed in surveys by Sujatha and Zaheruddeen (2002) and Krull and Basedow (2006). Early reports of pupation in fruit in India (Sengupta and Behura 1955, 1957) probably mistakenly refer to larvae undergoing pre-pupal diapause.

Ability of the pest to survive transport and storage

- Red-banded mango caterpillar completes the larval stages of its lifecycle inside the mango fruit where the early instars feed on the pulp and later instars feed on the seed (Tenakanai *et al.* 2006). As an internal pest feeding on mango fruit, red-banded mango caterpillar is likely to survive during transport and storage.
- Red banded mango caterpillar may undergo a pre-pupal diapause within the fruit during the off-season season (Sujatha and Zaheruddeen 2002). This may favour its survival in fruit transport and storage.
- Larvae take 14 – 20 days to develop through the five instar phases before exiting the fruit to pupate (Golez 1991).

Ability of the pest to survive existing pest management procedures

- Infestation of fruit by red-banded mango caterpillar can be controlled by insecticidal sprays (Golez 1991). However, these will not have any impact on the larvae inside the mango seed.

The ability of the pest to survive management procedures, its cryptic life cycle inside the fruit and ability to develop there undetected for a considerable period (particularly in the case of late infestations), moderated by the likelihood of infested fruit reaching the packing stage supports an entry assessment of 'moderate'.

Probability of distribution

The likelihood that red-banded mango caterpillar will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of mango fruit from India, is: **MODERATE**.

Ability of the pest to move from the pathway to a suitable host

- Larvae of red-banded mango caterpillar feed internally on mango fruit pulp and seed (Krull and Basedow 2006; Tenakanai *et al.* 2006). If the larvae or pupae were to survive cold storage they would need to complete development and then find a suitable site to pupate. Adults emerge after 9 – 14 days pupation (Golez 1991).
- While the imported fruit would be a suitable site for development, this would need to be completed before fruit is either destroyed, eaten or decomposes.

- Red-banded mango caterpillar has limited hosts (Peña and Mohyuddin 1997; Krull and Basedow 2006), a short life cycle of less than one month and may have 3 – 4 generations during the mango season (Sujatha and Zaheruddeen 2002).
- Adult moths are possibly not capable of flying long distances (Sujatha and Zaheruddeen 2002; Gibb *et al.* 2007). Adults are short lived; mean of 2.5 days for females and 2.9 days for males in a study by Sujatha and Zaheruddeen (2002). Krull (2004) reported that adult moths live for about 9 days.

Distribution of the imported commodity in the PRA area

- Mangoes are likely to be distributed to multiple destinations throughout Australia for retail sale. The ability of the pest to develop within the fruit would allow it to survive this distribution. Wholesalers, retailers or consumers could discard spoiled fruit distributing larvae to multiple locations.
- During the winter period, the species may undergo pre-pupal diapause (Sujatha and Zaheruddeen 2002) or survive in pupal cocoons (Krull and Basedow 2006). Its ability to undergo diapause may assist the distribution of this species.

Risks from by-products and waste

- The intended use of the commodity is for human consumption but waste material will be generated. Larvae in infested mangoes could complete development in discarded waste.
- Larvae complete their development inside the fruit (Peña and Mohyuddin 1997) and pupation occurs outside the fruit (Tenakanai *et al.* 2006); dead wood, cracks and crevices on the bark are pupation sites (Sujatha and Zaheruddeen 2002).
- Larvae may also pupate in packing material (CAB International 2007). If this packing material is reused for mango, cross infestation could occur.

Since the draft report (DAFF 2004), Biosecurity Australia has reassessed the probability of distribution for red-banded mango caterpillar, moving it from 'high' to 'moderate', following reconsideration of the impact of restricted host range and dispersal behaviour (from waste to suitable host) on the risk estimate. It is considered that, given the cryptic life-cycle of the pest inside the fruit, the factors affecting distribution are similar to those affecting entry, and a similar risk rating is warranted.

Probability of entry (importation x distribution)

The overall probability of entry for red-banded mango caterpillar is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for red-banded mango caterpillar is estimated to be: **LOW**.

4.9.2. Probability of establishment

The likelihood that red-banded mango caterpillar will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **MODERATE**.

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- Red-banded mango caterpillar is capable of surviving and reproducing on *Mangifera indica, M. minor*, *M. odorata* and *Bouea burmanica* all in the Anacardiaceae family (Tenakanai *et al.* 2006). *Mangifera* species are grown widely in tropical areas of Australia as ornamental, shade and fruit trees (Maynard *et al.* 2004).

Suitability of the environment

- The distribution of red-banded mango caterpillar includes India, South-East Asia, Papua New Guinea and the northern tip of Cape York Peninsula in Queensland, Australia (Krull and Basedow 2006; Tenakanai *et al.* 2006). It is likely that other suitable environments occur in Australia especially in warmer tropical and sub-tropical environments where mango is grown.
- Optimum conditions for the development of red-banded mango caterpillar range from 16.7 – 35°C and a relative humidity above 87% (CAB International 2007).

The reproductive strategy and survival of the pest

- Female moths produce sex pheromones that attract males (Gibb *et al.* 2007). This increases the chances of individuals being able to find a suitable mate, even at low initial densities.
- Oviposition occurs as early as 45 to 55 days after flower induction and continues up to fruit maturity (Waterhouse 1998). The preferred oviposition site is under the sepals of developing fruit (Krull 2004; Krull and Basedow 2006).
- In India, red-banded mango caterpillar has a life cycle of less than one month, with 3 – 4 generations during the mango season (Sujatha and Zaheruddeen 2002). Adults are generally nocturnal and during the day spend most of their time resting under leaves on the tree (Waterhouse 1998).
- Red-banded mango caterpillar may diapause (pre-pupal) overwinter (Sujatha and Zaheruddeen 2002). Pupation occurs on the deadwood, cracks or crevices in the bark of the host tree (Sujatha and Zaheruddeen 2002; Krull 2004; Krull and Basedow 2006; B. Pinese 2008, pers. comm.), or soil (Golez 1991). The emergence of adults may be initiated by physiological changes within the mango tree associated with flowering onset and fruit development (Krull and Basedow 2006).
- In the absence of mango fruit, adults cannot reproduce in other parts of the mango tree or on other fruit species (Peña and Mohyuddin 1997; Krull 2004). Therefore the likelihood of establishment is limited to the fruiting period within mango areas.

Cultural practices and control measures

- To prevent infestation of fruit, insecticide spray regimes in commercial mango production areas must coincide with the larvae hatching from eggs prior to tunnelling into developing fruit (Golez 1991; Krull 2004). It is unlikely that suitable chemical control would be applied to host trees in urban or suburban areas. Therefore, it is unlikely that current control measures would impact on the establishment of red-banded mango caterpillar in Australia.

Since the draft report (DAFF 2004), Biosecurity Australia has reassessed the probability of establishment for red-banded mango caterpillar, moving it from ‘high’ to ‘moderate’, following reconsideration of the impact of restricted host range and the specific feeding and reproduction requirements on the risk estimate.

4.9.3. Probability of spread

The likelihood that red-banded mango caterpillar will spread within Australia, based on a comparison of those factors in the source and destination area considered pertinent to the expansion of the geographic distribution of the pest, is: **MODERATE**.

The suitability of the natural or managed environment for natural spread

- Red-banded mango caterpillar has been reported from a variety of tropical and subtropical environments. For example, red-banded mango caterpillar has a distribution from India,

South-East Asia to Australia, where it is currently restricted to the northern tip of Cape York Peninsula in Queensland (Peña and Mohyuddin 1997; Krull and Basedow 2006; Tenakanai *et al.* 2006).
- Based on its current distribution, it is likely that suitable habitats exist in Australia outside its current restricted occurrence.
- The spread of red-banded mango caterpillar within managed or natural environments is slow. The pest spreads on the initial host tree first and then on to other host trees (Krull 2004).

Presence of natural barriers
- The presence of natural barriers such as deserts or mountain ranges may prevent long-range natural spread of red-banded mango caterpillar.
- The significance of flight to the adults ability to disperse requires further study (Gibb *et al.* 2007), but it is likely that this is a significant factor in spread over short distances (e.g. within orchards and between closely spaced orchard areas). If red-banded mango caterpillar is introduced to major commercial production areas of Australia it is likely to slowly spread within that area.

Potential for movement with commodities or conveyances
- Transportation of infested fruit would aid the movement of the red-banded mango caterpillar between orchards and into new areas.
- Red-banded mango caterpillar has demonstrated a capacity to spread, from its original range in India-Myanmar through South-East Asia and Papua New Guinea (Krull and Basedow 2006; Tenakanai *et al.* 2006; CAB International 2007).
- This species has also spread to the Torres Strait and northern tip of Cape York where the only hosts of red-banded mango caterpillar are introduced mango trees grown for fruit production and shade (Maynard *et al.* 2004).

Potential natural enemies
- Several parasites and predators have been recorded as attacking red-banded mango caterpillar overseas (Krull and Basedow 2006). However, there are no natural enemies of red-banded mango caterpillar recorded in Australia likely to impede the spread of the species.
- Two species of egg parasitoids (*Trichogramma chilonis* and *T. chilotraeae*) and one larval predator species (*Rhychium attrisimum*) have been observed attacking immature stages of red-banded mango caterpillar in the Philippines, but with little effect (Golez 1991).
- Some other species have been mentioned in the literature as potential parasites including *Evania appendigaster*, *Carcelia* species, and an unidentified fungus, but their importance remains unknown (Krull 2004).

Since the draft report (DAFF 2004), Biosecurity Australia has reassessed the probability of spread for red-banded mango caterpillar in this Report, moving it from ‘high’ to ‘moderate’, following reconsideration of the impact of restricted host range and dispersal mechanisms on the risk estimate.

4.9.4. Overall probability of entry, establishment and spread

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

The overall probability that red-banded mango caterpillar will be imported as a result of trade in mango fruit from India, be distributed in a viable state to a susceptible host, establish and spread within Australia, is: **LOW**.

4.9.5. Consequences

The consequences of the entry, establishment and spread of red-banded mango caterpillar in Australia have been estimated according to the methods described in Table 2.3. The assessment of potential consequences is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D** – Significant at the district level. This pest can cause significant direct harm to mango production at the district level. In tropical parts of Asia, it causes commercial losses in the order of 10 – 15% (QDPIF 2005). • Red-banded mango caterpillar causes more damage than most other boring pests as larvae damage both the flesh and the seed (Golez 1991). • Secondary infection by other pests and pathogens is commonplace (Gibb *et al.* 2007). • The level of fruit infestations in Papua New Guinea has reached 20 – 40% (Tenakanai *et al.* 2006).
Other aspects of the environment	**B** – Minor significance at the local level. There are no known direct consequences of this pest on other aspects of the environment. The host range of Red-banded mango caterpillar is limited to *Mangifera indica, M. minor*, *M. odorata* and *Bouea burmanica* (Tenakanai *et al.* 2006).
Indirect	
Eradication, control etc.	**D** – Significant at the district level. A control program would have to be implemented in infested orchards to reduce fruit damage and yield losses and this would increase production costs. • A quarantine area has been established on Cape York Peninsula and the Torres Strait Islands north of 13° 45 'S latitude by the QDPIF to restrict the spread of red-banded mango caterpillar (QDPIF 2005). The Coen information and inspection centre enforce controls on mango fruit and plant movements (QDPIF 2005). • Control of red-banded mango caterpillar is difficult and it has not been successfully eradicated anywhere in the world (QDPIF 2005).
Domestic trade	**D** – Significant at the district level. The presence of red-banded mango caterpillar in commercial production areas will result in interstate trade restrictions on mango fruit. These restrictions may lead to a loss of markets and industry adjustment.
International trade	**E** – Significant at the regional level. The presence of red-banded mango caterpillar in commercial production areas of Australia is likely to limit access to overseas markets where this pest is absent.
Environmental and non-commercial	**B** – Minor significance at the local level. Although additional insecticide applications would be required to control red-banded mango caterpillar, this is not considered to have significant consequences for the environment.

Based on the decision rules described in Table 2 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**.

4.9.6. Unrestricted risk estimate

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

Unrestricted risk estimate for red-banded mango caterpillar	
Overall probability of entry, establishment and spread	**Low**
Consequences	**Moderate**
Unrestricted risk	**Low**

As indicated, the unrestricted risk for red-banded mango caterpillar has been assessed as ‘low’, which is above Australia’s ALOP. Therefore, specific risk management measures are required for this pest.

4.10. Mango thrips – *Rhipiphorothrips cruentatus* [Thysanoptera: Thripidae]

Mango thrips (*Rhipiphorothrips cruentatus*) are blossom pests, causing damage by laying eggs in the panicle and feeding on floral parts. Female mango thrips lay eggs on mature leaves and panicles (Lewis 1997). Nymphs and adults feed by puncturing and sucking cell contents from the epidermis of leaves and fruits of host plants (Srivastava 1997). Mango thrips have a wide range of hosts including grapevine, mango, guava, cashew nut, wax apple, almond, and pomegranate (Lewis 1997; Srivastava 1997; Dahiya and Lakra 2001).

Mango thrips can reproduce sexually and by parthenogenesis (Chiu 1984). The life cycle is temperature-dependent, with more eggs being produced, and life history lengths reduced, at high temperatures. In India, adults emerge from hibernating pupae in March, whereas in southern Taiwan the species continues to breed at various rates throughout the year (Rahman and Bharadwaj 1937; Chiu 1984).

4.10.1. Previous policy

Mango thrips have previously been assessed for the importation of mango from Taiwan with an unrestricted risk rating of ‘very low’. The existing policy for mango thrips is adopted for the importation of mango from India as the risks of importation and distribution are judged to be similar. Therefore, mango thrips is not considered further in this policy.

4.11. Mango malformation – *Fusarium mangiferae*

Mango malformation is a serious disease of mango in tropical and subtropical regions of the world (Steenkamp *et al.* 2000). The most prominent symptom is the deformation of shoots and flowers (Kumar *et al.* 1993). Floral malformation is characterised by thick, fleshy and profusely branched panicles that are covered by enlarged flowers (Kumar *et al.* 1993). The symptoms of the disease have been attributed to altered levels of the hormone cytokinin produced in the plant. These malformed panicles generally do not bear fruit because they remain very small or are aborted prematurely (Kumar *et al.* 1993; Varma *et al.* 1974). A second important symptom of this disease is the deformation of mature trees (Kumar *et al.* 1993). Nursery seedlings can also be infected and this is a common means by which the disease has spread to new areas (Freeman *et al.* 2004; Kumar *et al.* 1993).

Mango malformation has been reported in Africa (Egypt, South Africa, Sudan, Swaziland and Uganda), the Americas (Brazil, Cuba, El Salvador, Mexico, Nicaragua, USA and Venezuela) and Asia (Bangladesh, India, Israel, Malaysia, Pakistan and United Arab Emirates) (Kumar *et al.* 1993; Bains and Pant 2003; Marasas *et al.* 2006). Kumar *et al.* (1993) and Bains and Pant (2003) were wrong in concluding from their reading of Peterson (1986) that the disease was present in Australia, as there were no records of this disease in Australia at this time.

Until recently mango malformation was thought to result from infection by *Fusarium subglutinans* (Wollenw. & Reinking) P.E. Nelson, Toussoun & Marasas [synonyms: *Fusarium moniliforme* var. *subglutinans* Wollenw. & Reinking, *Fusarium neoceras* var. *subglutinans* (Wollenw. & Reinking) Raillo; *Fusarium sacchari* var. *subglutinans* (Wollenw. & Reinking) Nirenberg], *Fusarium verticillioides* (Sacc.) Nirenberg [synonym: *Fusarium moniliforme* J. Sheld.] or *Fusarium oxysporum* Schltdl. (Bhatnager & Beniwal 1977; Kumar *et al.* 1993).

Mango malformation is now known to be a disease syndrome caused by numerous species in the *Gibberella fujikuroi* species complex (O'Donnell *et al.* 1998; Britz *et al.* 2002). It appears that in different regions of the world different *Fusarium* anamorphs of members of the *G. fujikuroi* complex have adapted to *Mangifera indica* and are causing disease symptoms described as mango malformation. Two of these *Fusarium* species have been described and others will be in the near future (Britz *et al.* 2002). The pathogen associated with mango malformation in India is *Fusarium mangiferae* (Britz *et al.* 2002). This fungus also occurs in Egypt, Israel, Malaysia, South Africa and USA (Britz *et al.* 2002; Marasas *et al.* 2006). It is not known to infect plants other than mango.

Fusarium mangiferae produces both macro- and microconidia (Freeman *et al.* 2004) but is not known to produce chlamydospores (Ploetz *et al.*1994). Bud and flower tissues are primary infection sites and wounds provide points of entry for the pathogen (Freeman *et al.* 1999). It has been postulated that *Aceria mangiferae* (mango bud mite) may exacerbate the disease through the transfer of inoculum and providing wound sites on the plant which favour infection by *F. mangiferae* (Youssef *et al.* 2007).

The pathogen examined in this pest risk analysis is:
- *Fusarium mangiferae* – the causal agent of mango malformation disease in India

In late 2007, *F. mangiferae* was detected in a mango plantation near Darwin. The plantation has been felled and burnt and the disease is under official control (DPIFM 2008). However, there are no restrictions on the movement of fruit from the Northern Territory into other states or territories in Australia.

Mango malformation was not considered in the 2004 Draft document (DAFF 2004). An assessment of the pathogen has been provided below. The resultant risk rating has been determined to be 'very low'. However, given that India uses a hot water fungicidal dip as part of the existing commercial practices this would lower the rating even further.

4.11.1. Probability of entry

Probability of importation

The likelihood that *F. mangiferae* will arrive in Australia with the importation of fruit from India: **MODERATE**.

Association of the pest with the pathway at its origin

- *Fusarium mangiferae* is recorded in mango orchards in India as the causal agent of mango malformation (Kumar *et al.* 1993; Marasas *et al.* 2006). The pathogen affects vegetative shoots and floral panicles, resulting in distortion (phyllody and hypertrophy) (Iqbal *et al.* 2006b; Ploetz 1994).
- Infected panicles and shoots persist on trees and are a source of conidia (Kumar *et al.* 1993; Noriega-Cantú *et al.* 1999). Conidia production peaks with rains and conidia are probably splash dispersed (Kumar *et al.* 1993; Noriega-Cantú *et al.* 1999).
- Conidia may contaminate the fruit surface but infection of the flesh and seed is not known to occur (Freeman *et al.* 2004; Youssef *et al.* 2007). Studies indicate that fruit within a two metre radius of infected panicles can be contaminated with viable conidia (Freeman *et al.* 2004; Youssef *et al.* 2007). There is no evidence that *F. mangiferae* can be spread on mango fruit or mango seeds (DPIFM 2008).
- Infected panicles usually do not produce fruit (Kumar *et al.* 1993; Noriega-Cantú *et al.* 1999), or the fruits are aborted early (Kumar *et al.* 1993; Ploetz *et al.* 2002).
- Picked fruit could be surface-contaminated by: (a) pickers' hands or gloves getting contaminated with spores after touching infected panicles and (b) spores carried in rain splash and wind currents being deposited on clean fruit.
- Post-harvest cleaning and washing of the fruit is routinely employed in mango production in India to remove the sap that exudes from the stem end (Morton 1987). If any conidia of *F. mangiferae* are on the fruit at the time of harvest, some may be removed by this post-harvest practice.
- The existing commercial practice of hot fungicide dipping has not been taken into account in this unrestricted risk assessment.

Ability of the pest to survive transport and storage

- *Fusarium mangiferae* has not been recorded from the flesh or seeds of fruit, although they may be present on the fruit surface (Youssef *et al.* 2007). The level of fruit contamination is unlikely to increase by germination of spores and mycelial growth on the fruit surface during transit. Therefore, contamination of adjacent fruits is unlikely to occur.
- No information is available on the effect of environmental conditions on survival of macro- and microconidia of *F. mangiferae* during storage or transport. However, the growth and survival of conidia of other *Fusarium* species are affected by environmental conditions. For instance, macroconidia of *F. graminearum* do not germinate at relative humidities below 80% and lose viability after 90 hours at 53% relative humidity (Beyer *et al.* 2004).

Ability of the pest to survive existing pest management procedures

- The application of fungicides (Noriega-Cantú *et al.* 1999) and standard sanitation measures (Youssef *et al.* 2007) in the field may significantly reduce the incidence of infestation. However, panicles infected at low levels would not show visible symptoms and may escape standard sanitation measures (Iqbal *et al.* 2006a). Therefore, *F. mangiferae* is likely to survive the existing pest management procedures.

The risk of surface contamination of fruit with conidia is considered to warrant a risk rating for entry of 'moderate'.

Probability of distribution

The likelihood that *F. mangiferae* will be distributed within Australia as a result of the processing, sale or disposal of mango fruit from India: **VERY LOW**.

Ability of the pest to move from the pathway to a suitable host

- *Fusarium mangiferae* has a narrow host range, primarily limited to mangoes (Akhtar and Alam 2002). This host is present in urban and commercial production areas in tropical and subtropical parts of Australia where fruit might be disposed. However, the narrow host range decreases the probability of conidia being spread to a suitable host when conditions are favourable for infection.
- The distance the fungus could be dispersed from contaminated mango waste is limited, as conidia would need to be dispersed by water splash (or possibly wind) from discarded waste to a susceptible host.
- Suitable sites for infection include bud or flower tissues (Freeman *et al.* 2004; Youssef *et al.* 2007). Wounds also provide points of entry for the pathogen (Freeman *et al.* 1999).
- Mango fruits from India would arrive in Australia during autumn and winter. Imports would only overlap with flowering in the mango production areas of Darwin, Katherine, Kununurra and Carnarvon in arid tropical Australia (Poffley *et al.* 1999; Johnson and Parr 2008).
- Flowering in the mango production areas in Queensland and New South Wales occurs in spring, which is after the import season for Indian mangoes.

Distribution of the imported commodity in Australia

- The commodity would be distributed within Australia through its sale to various locations, so a portion of contaminated fruit may enter tropical and subtropical areas where mangoes are grown.
- The pathogen may survive storage and transport on the surface of the fruit as conidia.
- There is no information available on the survival of conidia on mango fruit in cold storage.

Risks from by-products and waste

- The intended use of the commodity is human consumption but waste material would be generated (e.g. skins of fruit, overripe fruit, damaged fruit and seed). There is no published information that *F. mangiferae* is seed-borne or that it can multiply on the fruit. The pathogen is known to contaminate the fruit externally but infection of the flesh is not reported (Freeman *et al.* 2004; Youssef *et al.* 2007).
- Discarded waste contaminated with fungal conidia would be rapidly colonized by other saprophytic micro-organisms. As *F. mangiferae* is a slow growing species (Kumar *et al.* 1993), it is likely to be out competed by these micro-organisms. Therefore, the chance of the fungus producing macro- or microconidia is low. Additionally, macro- or

microconidia of *Fusarium* species are short lived and are vulnerable to desiccation (Beyer *et al.* 2004).
- Survival of *F. mangiferae* in soil is poor, with 100% mortality in 102 days in winter conditions (14°C average) and close to 100% after 28 days in summer conditions (28°C average) (Freeman *et al.* 2004; Youssef *et al.* 2007).

Fusarium mangiferae has a narrow host range, produces only short lived macro- and microconidia and requires suitable sites to initiate infection. For *F. mangiferae* to enter and be distributed to suitable hosts in Australia, importation of contaminated fruit shortly after harvest and transfer of conidia from mango waste by water splash to susceptible hosts must occur. Therefore, a rating of 'very low' is allocated.

Probability of entry (importation x distribution)

The overall probability of entry for *Fusarium mangiferae* is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2. The overall probability of entry for *F. mangiferae* is estimated to be: **VERY LOW**.

4.11.2. Probability of establishment

The likelihood that *F. mangiferae* will establish based on a comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **MODERATE**.

Availability of suitable hosts, alternative hosts and vectors in Australia

- *Fusarium mangiferae* is capable of surviving and reproducing only on mango (Akhtar and Alam 2002; Britz *et al.* 2002) and this host is present in urban and commercial production areas in tropical and subtropical parts of Australia. Mango trees are grown for their fruits and for shade throughout northern Australia (Maynard *et al.* 2004).
- Conidia of *F. mangiferae* are dispersed by water splash, so a vector is not required.
- *Aceria mangiferae* (mango bud mite), which is thought to vector the pathogen (Youssef *et al.* 2007), is widespread on mangoes in Australia.

Suitability of the environment

- *Fusarium mangiferae* is distributed in a wide range of climates (Kumar *et al.* 1993; Ploetz *et al.* 2002), and regions of Australia are likely to be suitable for the establishment of these species (Espenshade 1990).
- *Fusarium mangiferae* occurred in a mango plantation near Darwin in the Northern Territory, demonstrating that the environment in regions of Australia is suitable for this fungus to establish.
- Infection requires the presence of new vegetative or inflorescence growth and high humidity and temperatures (Kumar *et al*. 1993; Ploetz *et al*. 2002). However, when flowering occurs during the dry season, such as in northern mango production areas in Australia, the potential for disease establishment is limited.

The reproductive strategy and survival of the pest

- *Fusarium mangiferae* reproduces asexually, producing conidia (Freeman *et al.* 2004). No sexual stage is known (Britz *et al.* 2002).
- *Fusarium mangiferae* survives in the infected host tissues (i.e. flowers and buds) and produces conidia on infected tissues (Kumar *et al.* 1993; Noriega-Cantú *et al.* 1999).

- Pathogen populations in infected plant debris (i.e. old panicles) decline more rapidly on the soil surface than when they are buried in the soil (Freeman *et al.* 2004; Youssef *et al.* 2007).
- Survival of the pathogen inside of plant debris declines rapidly (Freeman *et al.* 2004).
- Survival of *F. mangiferae* in soil is poor with 100% mortality in 102 days in winter conditions (14°C average) and close to 100% after 28 days in summer conditions (28°C average) (Freeman *et al.* 2004; Youssef *et al.* 2007).

Cultural practices and control measures

- Standard measures include sanitation, whereby infected panicles and branches are removed and destroyed to reduce disease spread and the build up of pathogen inoculum (Youssef *et al.* 2007). However, symptoms may not be visible at low levels (Iqbal *et al.* 2006a) and typical symptoms are only visible when significant amounts of mycelia colonise the stems and inflorescences (Iqbal *et al.* 2006a). Therefore, *F. mangiferae* is likely to survive the existing pest management procedures.

The suitability of the environment, narrow host range, asexual reproduction and requirement of susceptible host tissues, support an establishment rating of ‘moderate’.

4.11.3. Probability of spread

The likelihood that *F. mangiferae* will spread based on a comparative assessment of those factors in the source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **MODERATE**.

The suitability of the natural or managed environment for natural spread

- *Fusarium mangiferae* has been reported in the tropics (India, Malaysia, Pakistan), sub-tropics (South Africa and USA) and Mediterranean (Egypt and Israel) regions (Britz *et al.* 2002; Iqbal *et al.* 2006b; Marasas *et al.* 2006). Similar climates occur in parts of Australia. This suggests that *F. mangiferae* could spread within Australia.

Presence of natural barriers

- The presence of natural barriers such as deserts or mountain ranges may prevent long-range natural spread of *F. mangiferae*. *Fusarium mangiferae* is limited to short distance dispersal by splashed/blown conidia (Freeman *et al.* 2004; Youssef *et al.* 2007).
- Spread may be assisted by *Aceria mangiferae* (mango bud mite) (Kumar *et al.* 1993; Youssef *et al.* 2007), which is present in Australia.
- Hosts of *F. mangiferae* are located in many parts of tropical Australia. Natural barriers, such as arid areas, climatic differentials and long distances exist between these areas. The long distances between commercial mango orchards in Australia may prevent long-range natural spread of this fungus.
- If this fungus is introduced to major commercial production areas of Australia, such physical barriers are unlikely to be a limiting factor to the spread. *Fusarium mangiferae* has the potential to gradually spread by human activity, thereby expanding the range of infestation to all mango fruit production areas in Australia.

Potential for movement with commodities or conveyances

- Movement of infected planting material is the main pathway by which *F. mangiferae* has been introduced to other countries (Kumar *et al.* 1993). Indeed, the introduction of the pathogen to the United Arab Emirates was linked to the importation of infected seedlings (Burhan 1991).

- Detection of spores of *Fusarium* species with mango pollen grains indicates that the pathogen may also be spread by pollen assisted by wind or insect vectors (Freeman *et al.* 1999).
- Existing interstate quarantine control on the movement of nursery stock could reduce the rate of spread of this pathogen. However, similar measures are not usually applied for the movement of propagative material within a state.

Potential natural enemies

- There is no published information available on natural enemies of *F. mangiferae*.

The limited ability of *F. mangiferae* to spread from infested orchards, due to its short lived conidia, moderated by its potential spread on mango propagative material support a spread rating of 'moderate'.

4.11.4. Overall probability of entry, establishment and spread

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

The overall probability that *F. mangiferae* will enter Australia as a result of trade in mango fruit from India and be distributed in a viable state to suitable hosts, establish and subsequently spread, is: **VERY LOW**.

Biosecurity Australia notes that this assessment is in agreement with the Australian Mango Industry Biosecurity Plan for the risk of introducing this pathogen with mango fruit.

4.11.5. Consequences

The consequences of the entry, establishment and spread of *F. mangiferae* in Australia have been estimated according to the methods described in Table 2.3. The assessment of potential consequences is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E** – Significant at the regional level. Mango malformation disease (MMD) is estimated to have consequences that are significant at the regional level. • MMD is considered to be one of the most important diseases of mango worldwide (Youssef *et al.* 2007). Trees infected with *F. mangiferae* have malformed inflorescences, a reduction in the number of female flowers and an increase in the number of sterile flowers (Marasas *et al.* 2006). In Pakistan, all of these factors reduce the yield in the order of 60–90% (Iqbal *et al.* 2006b).
Other aspects of the environment	**A** – Indiscernible at the local level. There are no known direct consequences of this pathogen on other aspects of the environment. The host range of this pathogen is limited to mango (Akhtar and Alam 2002; Britz *et al.* 2002).

Indirect	
Eradication, control etc.	**D** – Significant at the district level. Additional programs to minimise the impact of this pathogen on host plants would be necessary. Changes would be required to orchard maintenance programs. • There have been conflicting reports as to the efficacy of fungicides in the control of mango malformation (Kumar *et al.* 1993). The application of any fungicides for the control of *F. mangiferae* imposes additional cost to the producer. The identification of *F. mangiferae* in the Northern Territory in late 2007 has resulted in quarantine measures to eradicate the pathogen. These measures have been implemented with significant cost to the Northern Territory government.
Domestic trade	**D** – Significant at the district level. The presence of this pathogen in commercial production areas may have a significant effect at the district level because of trade restrictions on nursery stock. These restrictions can inhibit the adoption of new varieties, which in turn would cause disruption to mango production.
International trade	**B** – Minor significance at the local level. The presence of this pathogen in commercial production areas of mango would not have any impact on trade in mango fruit but could have minor significance at the local level for export of nursery stock to countries free of this pathogen.
Environmental and non-commercial	**A** – Indiscernible at the local level. Although additional fungicide applications would be required to control this pathogen, this is not considered to have significant consequences for the environment.

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 estimated to be: **MODERATE**.

4.11.6. Unrestricted risk estimate

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

Unrestricted risk estimate for *F. mangiferae*	
Overall probability of entry, establishment and spread	**Very Low**
Consequences	**Moderate**
Unrestricted annual risk	**Very low**

As indicated, the unrestricted risk for *F. mangiferae* has been assessed as ‘very low’, which meets Australia’s ALOP. Therefore, specific risk management measures are not required for this pathogen. Furthermore, the use of a hot water fungicidal dip in India as part of the existing commercial practices would lower the rating even further.

4.12. Mango scab – *Elsinoë mangiferae*

Mango scab was first reported from Cuba and Florida. Now it is found in most of the mango growing areas around the world, including South-East Asia (Conde *et al.* 2007). Mango scab was first identified in Australia in 1997, near Darwin. It appears to have been in the Northern Territory and Queensland since at least the early 1990s but was thought to be a form of flower anthracnose (Conde *et al.* 2007). Members of the genus *Elsinoë* are biotrophs, which means that they will only survive on living plant tissue. Young leaf, twig, flower and fruit tissues are especially susceptible to infection. For instance, fruit is no longer susceptible after it reaches about half size (Conde *et al.* 2007).

Young, succulent tissues are preferentially infected (Ploetz *et al.* 1994). In general, host tissues become increasingly resistant as they mature. High humidity and free moisture are required for the production of spores and for host infection (Ploetz *et al.* 1994). *Elsinoë mangiferae* produces two types of spores: ascospores (the sexual stage); and conidia (the asexual stage). The asexual life stage is sometimes referred to by a different name: *Denticularia mangiferae*. There are no reports of it affecting plants other than mango (Ploetz *et al.* 1994).

4.12.1. Previous policy

The pathogen *E. mangiferae* has previously been assessed, as a quarantine pest, only for Western Australia, for the importation of mangoes from Taiwan with an unrestricted risk rating of 'very low'**.** The existing policy for *E. mangiferae* is adopted for the importation of mango from India as the risks of importation and distribution are judged to be similar. Therefore, mango scab is not considered further in this policy.

4.13. Risk assessment conclusion

Table 4.2 summarises the detailed risk assessments and provides unrestricted risk estimates for the quarantine pests considered to be associated with mango fruits from India.

Fruit fly species with mango as a preferred host (*Bactrocera caryeae*, *B. correcta, B. dorsalis B. invadens* and *B. zonata*) were assessed to have an unrestricted risk estimate of 'high'.

Melon fruit fly (*Bactrocera cucurbitae*), mango weevils (*Sternochetus frigidus* and *Sternochetus mangiferae*), mealybugs (*Ferrisia virgata, F. malvastra*, *Planococcus lilacinus, Rastrococcus iceryoides, R. invadens* and *R. spinosus*) and red-banded mango caterpillar (*Deanolis sublimbalis*) were assessed to have an unrestricted risk estimate of 'low'. The unrestricted risk estimates for these pests exceed Australia's appropriate level of protection. Specific risk management measures are therefore required for the import of fresh mango fruits from India into Australia to adequately address the potential quarantine risk.

Armoured scales (*Abgrallaspis cyanophylli* and *Parlatoria crypta*), pumpkin fruit fly (*Bactrocera tau*), mango thrips (*Rhipiphorothrips cruentatus*), mango malformation disease syndrome (*Fusarium mangiferae*) and mango scab (*Elsinoë mangiferae*) were assessed to have an unrestricted risk estimate of 'very low' and therefore do not require the application of any specific phytosanitary measures in order to maintain Australia's appropriate level of protection.

Tussock moth (*Orgyia postica*) was assessed to have an unrestricted risk estimate of 'negligible' and therefore does not require the application of any specific phytosanitary measures in order to achieve Australia's appropriate level of protection.

Table 4.2: Summary of pest risk assessments for quarantine pests for fresh mango fruit from India

*Regional quarantine pests have the endangered area identified in parentheses.

Pest name	Probability of					Overall probability of entry, establishment or spread	Consequences	Unrestricted risk
	Entry			Establishment	Spread			
	Importation	Distribution	Overall (importation x distribution)					
Coleoptera: Curculionidae (weevils)								
Sternochetus frigidus	High	Low	Low	Moderate	Moderate	Low	Moderate	Low
Sternochetus mangiferae (WA)	High	Low	Low	Moderate	Moderate	Low	Moderate	Low
Diptera: Tephritidae (fruit flies) – Mango as a preferred host								
Bactrocera caryeae	High	High	High	High	High	High	High	High
Bactrocera correcta	High	High	High	High	High	High	High	High
Bactrocera dorsalis	High	High	High	High	High	High	High	High
Bactrocera invadens	High	High	High	High	High	High	High	High
Bactrocera zonata	High	High	High	High	High	High	High	High
Diptera: Tephritidae (fruit flies) – Mango as a non-preferred host								
Bactrocera curcurbitae	Very Low	High	Very low	High	Moderate	Very low	High	Low
Bactrocera tau	Extremely low	High	Extremely low	High	Moderate	Extremely low	High	Very low
Hemiptera: Diaspididae (armoured scales)								
Abgrallaspis cyanophylli (WA)	High	Low	Low	High	Moderate	Low	Low	Very low
Parlatoria crypta	High	Low	Low	High	Moderate	Low	Low	Very low
Hemiptera: Pseudococcidae (mealybugs)								
Ferrisia malvastra (WA)	High	Moderate	Moderate	High	High	Moderate	Low	Low
Ferrisia virgata (WA)	High	Moderate	Moderate	High	High	Moderate	Low	Low
Planococcus lilacinus	High	Moderate	Moderate	High	High	Moderate	Low	Low

Pest name	Probability of					Overall probability of entry, establishment or spread	Consequences	Unrestricted risk
	Entry			Establishment	Spread			
	Importation	Distribution	Overall (importation x distribution)					
Rastrococcus iceryoides	High	Moderate	Moderate	High	High	Moderate	Low	Low
Rastrococcus invadens	High	Moderate	Moderate	High	High	Moderate	Low	Low
Rastrococcus spinosus	High	Moderate	Moderate	High	High	Moderate	Low	Low
Lepidoptera: Lymantridae (Moths)								
Orgyia postica	Low	Low	Very low	Moderate	Moderate	Very low	Low	Negligible
Lepidoptera: Pyralidae (Caterpillar)								
Deanolis sublimbalis	Moderate	Moderate	Low	Moderate	Moderate	Low	Moderate	Low
Thysanoptera: Thripidae (Thrips)								
Rhipiphorothrips cruentatus	Moderate	Moderate	Low	High	High	Low	Low	Very low
Fungi								
Elsinoë mangiferae (WA)	Low	Moderate	Low	Moderate	Moderate	Low	Low	Very low
Fusarium mangiferae	Moderate	Very low	Very low	Moderate	Moderate	Very low	Moderate	Very low

5. Pest risk management

Biosecurity Australia considers that the risk management measures recommended in this Report, implemented in conjunction with the operational system for the maintenance and verification of the quarantine status of fresh mango fruit for human consumption from India, will achieve Australia's ALOP.

Visual inspection alone is not considered to be an acceptable measure to verify the level of infestation of fresh mango fruit with mango pulp weevil, mango seed weevil or fruit flies and therefore another measure is required for these pests. This is because clear visual external signs of infestation (particularly in recently infested fruit) may not be present. Infestation in the egg or early instar stage is difficult to detect even when signs of infestation are being targeted during inspection.

The risks of entry, establishment and spread of mango weevils or fruit flies associated with the importation of fresh mango fruit from India would not achieve Australia's ALOP if visual inspection was the only measure applied. This is because failure to verify the level of infestation of the fruit is likely to result in the presence of unacceptable levels of these pests in the fresh mango fruit.

The 2004 draft report (DAFF 2004) proposed vapour heat treatment or hot water treatment for fruit flies and the use of designated 'pest free areas' for mango weevils. Visual inspection and remedial action was proposed for red-banded mango caterpillar and mealybugs.

In October 2006, India requested that Australia allow irradiation as a measure for pests of fresh mango fruit. India also advised Australia in November 2006 that it was not in a position to establish areas free from mango weevils or fruit flies.

Australia has therefore considered the measure of irradiation, requested by India, to manage the identified quarantine pests for fresh mango fruit from India. Because the recommended irradiation dose rate (outlined below) is sufficient to mitigate the risks posed by all identified arthropod pests, the use of other alternative measures, including those proposed in the 2004 draft report (DAFF 2004) are therefore redundant under these circumstances.

The quarantine measures required to reduce the risks posed by all quarantine pests identified in this Report (Table 5.1) to achieve Australia's ALOP are described in the following sections. This risk analysis and the recommended measures are based on India's existing commercial production practices as set out in Chapter 3. The existing commercial production practice of a post-harvest fungicidal dip is a requirement for export to Australia.

The following measures will form the basis of the import conditions for fresh mango fruit from India. However, Biosecurity Australia does recognise that other risk management measures (including some of those identified above) may be suitable to manage the identified risks. Australia will consider measures proposed by India consistent with relevant international standards that would provide an equivalent level of protection.

5.1. Risk management measures

The following risk management measures and phytosanitary procedures are recommended to mitigate the risks identified in the pest risk assessments. These measures form the basis of the final import conditions for fresh mango fruit from India.

1. pre-export irradiation treatment at a minimum absorbed dose rate of 400 Gy for mango pulp weevil, mango seed weevil, fruit flies, red-banded caterpillar and mealybugs; and

2. operational systems for the maintenance and verification of the phytosanitary status of fresh mango fruit from India

5.1.1. Pre-export irradiation treatment at 400 Gy for mango pulp weevil, mango seed weevil, fruit fly species, red-banded caterpillar and mealybug species

The following pests were found to require specific risk management as the unrestricted risk exceeds Australia's ALOP.

Table 5.1: Phytosanitary measures proposed for quarantine pests for fresh mango fruit from India

Pest	Common name	Measure
Weevils [Coleoptera: Curculionidae]		Irradiation at 400 Gy
Sternochetus frigidus	Mango pulp weevil	
Sternochetus mangiferae (WA)	Mango seed weevil	
Fruit flies [Diptera: Tephritidae]		
Bactrocera caryeae		
Bactrocera correcta	Guava fruit fly	
Bactrocera cucurbitae	Melon fruit fly	
Bactrocera dorsalis	Oriental fruit fly	
Bactrocera invadens		
Bactrocera zonata	Peach fruit fly	
Mealybugs [Hemiptera: Pseudococcidae]		
Ferrisia virgata (WA)	Striped mealybug	
Ferrisia malvastra (WA)	Malvastrum mealybug	

Pest	Common name	Measure
Planococcus lilacinus	Coffee mealybug	Irradiation at 400 Gy
Rastrococcus iceryoides	Downey snowline mealybug	
Rastrococcus invadens	Mango mealybug	
Rastrococcus spinosus	Philippine mango mealybug	
Caterpillar [Lepidoptera: Pyralidae]		
Deanolis sublimbalis	Red-banded mango caterpillar	
If applicable, Australian regional quarantine pests are indicated with the region(s) concerned in parentheses		

The International Plant Protection Convention (IPPC) acknowledges the application of ionising irradiation as a phytosanitary treatment for regulated pests or articles in the ISPM 18: *Guidelines for the use of irradiation as a phytosanitary measure* (FAO 2006c). Irradiation dose rates up to a maximum of 1000 Gy are permitted for quarantine purposes for a range of tropical fruits, including mango, in the Australia New Zealand Food Standards Code.

Following existing commercial grading and sanitation procedures, all consignments of fresh mango fruit are to be irradiated prior to export. Irradiation as a phytosanitary measure for fresh mango fruit from India is to be applied to achieve a minimum response of sterility in the targeted pests.

Australia will require mango fruit to receive a minimum absorbed dose rate of 400 Gy and for this to be applied in accordance with ISPM 18 (FAO 2006c).

A minimum absorbed dose rate of 400 Gy is required for mango pulp weevil in view of the lack of specific data supporting a lower irradiation dose. The minimum absorbed dose rate of 400 Gy is considered sufficient to achieve sterility for all the quarantine arthropod pests identified in this IRA.

Note that lower irradiation doses would be appropriate for fruit flies (150 Gy) (Bustos *et al.* 2004; Follet and Armstrong 2004) and mango seed weevil (300 Gy) (Follett 2001). This is consistent with minimum dose rates approved by the USA (71 FR 4451-4464, Docket No. 03-077-2). In particular, the US has approved 150 Gy as a generic minimum dose rate for fruit fly, 300 Gy as a specific minimum dose rate for mango seed weevil and 400 Gy as a minimum generic dose rate for the class *Insecta* (except pupae and adults of the Order Lepidoptera).

India formally advised Australia in January 2007 that it is prepared to treat fresh mango fruit for export to Australia at the minimum absorbed dose rate of 400 Gy to mitigate the risk from arthropod pests. In November 2007, India advised that irradiation would take place in combination with a post-harvest fungicidal dip (prochloraz) undertaken for quality purposes (to control post-harvest storage rots and to extend shelf-life). Hot-water treatment of fruit is carried out in treatment tanks fitted with thermostatic controls to maintain a constant temperature of 52ºC.

Australia is prepared to review the minimum absorbed dose rate of 400 Gy if appropriate and acceptable efficacy data becomes available demonstrating that a lower dose is effective against the identified quarantine pests.

Approval for irradiation treatment is subject to availability of suitable equipment and facilities to carry out the treatment. All irradiation facilities must be accredited by AQIS.

Subject to appropriate verification of the integrity of the irradiation treatment system, the risk of entry, establishment and spread of arthropod pests associated with the importation of fresh mango fruit from India that has been irradiated at a minimum absorbed dose of 400 Gy would be negligible.

In the absence of appropriate verification of the integrity of the irradiation treatment system, the risk of entry, establishment and spread of arthropod pests associated with the importation of fresh mango fruit from India that has been irradiated at 400 Gy would not achieve Australia's ALOP. This is because failure to adequately treat the mango fruit is likely to result in the presence of viable arthropod pests in the fruit.

5.1.2 Operational systems for the maintenance and verification of the phytosanitary status of fresh mango fruit from India

A system of operational procedures is necessary to maintain and verify the phytosanitary status of fresh mango fruit from India. This is to ensure that the recommended risk management measures have been met and are maintained.

It is recommended that India's NPPO, or other relevant agency nominated by the NPPO, prepare a documented Work Plan for approval by AQIS that describes the phytosanitary procedures for the pests of quarantine concern for Australia and the various responsibilities of all parties involved in meeting this requirement.

The components of the recommended operational system for inclusion in the work plan are described below.

Recognition of the competent authority

India's Directorate of Plant Protection, Quarantine and Storage (PPQS), Ministry of Agriculture, is the designated NPPO under the International Plant Protection Convention (IPPC).

The objectives of the NPPO are to ensure that:

- service and certification standards, and Work Plan procedures, are met by all relevant agencies participating in this program; and
- the administrative processes are established that provide assurance that the requirements of the program are being met.

Requirement for pre-clearance

The objectives of the requirement for pre-clearance are to ensure that:

- the quarantine measures, including product identification, direct verification of irradiation treatments, AQIS inspection requirements, product security and documentation are met.

Packaging and labelling

The objectives of the requirement for packaging and labelling are to ensure that:

- mangoes exported to Australia are 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 the mango 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 to prevent post-irradiation infestation;
- the packaged mango fruit is labelled in such a way as to identify the treatment facility and other identifying features for the purposes of trace-back in the event that this is necessary; and
- the pre-cleared status of mango fruit is clearly identified.

Pre-export Phytosanitary inspection

The objectives of the requirement for pre-export phytosanitary inspection are to ensure that:

- fruit inspections undertaken by the NPPO, or other relevant agency nominated by the NPPO, and AQIS are completed after commercial grading and sanitation and before irradiation; and
- visual inspection of fresh mango fruit focuses on soil, animal and plant debris and other quarantine contaminants rather than quarantine pests that will be sterilised by irradiation.

Remedial action - pre-export phytosanitary inspection

The objectives of the requirement for remedial action following pre-export phytosanitary inspection are to ensure that:

- any quarantine risk associated with an identified quarantine pest that has not been identified in this PRA is addressed; and
- the consignment is free from soil, animal and plant debris and other quarantine contaminants.

Accreditation of treatment providers and auditing of procedures

The objective of the requirement for accreditation of treatment providers and auditing of procedures is to ensure that:

- treatment providers for the mandatory irradiation of mango fruit are accredited by AQIS and registered with the NPPO, or other relevant agency nominated by the NPPO, for this purpose before their export activity commences and comply with the current NPPO standards for export grade facilities and ISPM 18 (FAO 2006c).

Pre-export irradiation

The objective of the requirement for pre-export irradiation is to ensure that:

- any quarantine pests assessed as being above Australia's ALOP that may be present in a consignment of mango fruit for export to Australia are sterilised by an absorbed minimum dose of 400 Gy.

Storage and movement

The objectives of the requirements for storage and movement are to ensure that:

- product security is maintained during loading, transport, export consignment consolidation and shipping, sufficient to protect the consignment from pest contamination;

- there is no substitution or cross infestation of the product following AQIS pre-clearance inspection and direct verification of irradiation treatment; and
- consignments not shipped directly from one port or city in India to a designated port or city in Australia are in sealed containers.

Phytosanitary certification by the NPPO, or other relevant agency nominated by the NPPO

The objectives of the requirements for phytosanitary certification by the NPPO, or other relevant agency nominated by the NPPO, are to ensure that:

- an International Phytosanitary Certificate (PC) is issued for each consignment upon completion of pre-export inspection and treatment to verify that the relevant measures have been undertaken off-shore;

Remedial action(s) for non-compliance – on-arrival verification

The objectives of the requirements for remedial action(s) for non-compliance during on-arrival verification are to ensure that:

- any quarantine risk is addressed by remedial action, as appropriate, for consignments that do not comply with import requirements.

5.2. Review of policy

Australia reserves the right to review and amend the import policy if circumstances change.

Australia is prepared to review the policy after a substantial volume of trade has occurred.

The NPPO, or other relevant agency nominated by the NPPO, must inform Biosecurity Australia and/or the AQIS immediately on detection of any new pests of mango that are of potential quarantine concern to Australia.

6. Conclusion

This Report recommends that the importation of fresh mango fruit to Australia from India be permitted, subject to specific quarantine measures.

The recommendations of the Report are based on a comprehensive analysis of relevant scientific literature with reference to existing policy for the import of mangoes from Haiti, Mexico, the Philippines (Guimaras Island) and Taiwan, where relevant.

In the course of preparing the Report, Biosecurity Australia considered submissions from stakeholders on the 2004 draft report (DAFF 2004). All scientific issues raised in stakeholder submissions and material matters have been incorporated as appropriate.

The Report has identified fruit flies, mealybugs, red-banded mango caterpillar and mango weevils as pests that require quarantine measures to manage risks to a very low level in order to achieve Australia's appropriate level of protection. The existing commercial production practice of a post-harvest fungicidal dip, as advised by India to support its market access application, is an underlying requirement for export to Australia.

The Report recommends pre-export irradiation treatment at a minimum absorbed dose rate of 400 Gy which will achieve sterility for the identified quarantine pests. The treatment will be supported by an operational system to maintain and verify quarantine status including pre-clearance inspection and direct verification of the irradiation treatment by the Australian Quarantine and Inspection Service.

Quarantine measures proposed in the 2004 draft report (DAFF 2004), including vapour heat treatment, hot water treatment and pest free areas, have not been further considered as India has requested irradiation.

Three pests (mango seed weevil and two mealybug species) that are present in eastern Australia have been identified as quarantine pests for the state of Western Australia only. The recommended quarantine measures take account of these regional differences for Western Australia.

Biosecurity Australia will recommend to Australia's Director of Animal and Plant Quarantine that mango fruit be permitted entry into Australia from India subject to the above quarantine measures.

Appendices

Appendix A.1: Initiation and pest categorisation

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
ARACHNIDA: ACARINA					
Acaridae					
Tyrolichus casei Oudemans, 1910	Cheese mite	Yes – (Chakrabarti *et al.* 1997)	Yes – (AICN 2004)		No
Tyrophagus longior (Gervais, 1844)	Seed mite	Yes – (Mohanasundaram and Parameswaran 1991)	Yes – (AICN 2006)		No
Eriophyidae					
Aceria mangiferae Sayed, 1946	Mango bud mite	Yes – (DPP 2000)	Yes – (Halliday 1998)		No
Cisaberoptus kenyae Keifer, 1966	Mango leaf mite	Yes – (DPP 2001; Rai *et al.* 1993)	Yes – (Knihinicki and Boczek 2002)		No
Metaculus mangiferae (Attiah, 1955)	Mango rust mite	Yes – (Jeppson *et al.* 1975)	No – (Halliday 1998)	No[2] – Bud, inflorescence, leaf (Abou-Awad 1981; Jeppson *et al.* 1975)	No
Neocalacarus mangiferae Channabasavanna, 1966	Mite	Yes – (USDA 2001)	Yes – (Knihinicki and Boczek 2002)		No
Tegonotus mangiferae (Keifer)	Mango leaf rust mite	Yes – (Chakrabarti & Mondal, 1982)	Yes – (Knihinicki & Boczek, 2002)		No
Tarsonemidae					
Polyphagotarsonemus latus (Banks, 1904)	Broad mite	Yes – (USDA 2001)	Yes – (Halliday 1998; Hely *et al.* 1982)		No
Tenuipalpidae					
Brevipalpus californicus (Banks, 1904)	Citrus flat mite	Yes – (Murthy *et al.* 1979)	Yes – (Halliday 1998)		No
Brevipalpus obovatus Donnadieu, 1875	Privet mite	Yes – (CAB International 2007)	Yes – (APPD 2007)		No
Brevipalpus phoenicis (Geijskes, 1939)	False spider mite	Yes – (CAB International 2007)	Yes – (Halliday 1998; Hely *et al.* 1982)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Raoiella macfarlanei Pritchard & Baker, 1958	False spider mite	Yes – (Butani 1993)	No – (Halliday 1998)	No[2] – Leaf (Butani 1993)	No
Tetranychidae					
Oligonychus coffeae (Nietner, 1861)	Tea red spider mite; red coffee mite; red tea mite	Yes – (USDA 2001)	Yes – (Rand and Schicha 1981; Gutierrez and Schicha 1985)		No
Oligonychus mangiferus (Rahman & Sapra, 1940)	Mango red spider mite	Yes – (Zaman and Maiti 1994)	Yes – (Halliday 1998)		No
Panonychus ulmi (Koch, 1936)	European red spider mite	Yes – (CAB International 2007)	Yes – (CAB International 2007)		No
Tetranychus cinnabarinus (Boisduval, 1867)	Carmine spider mite	Yes – (Patel *et al*. 1997)	Yes – (Halliday 1998)		No
Tetranychus neocaledonicus (Andre, 1933)	Vegetable spider mite	Yes – (USDA 2001)	Yes – (AICN 2006)		No
INSECTA: COLEOPTERA					
Alticidae					
Chaetocnema cognatata Baly	Flea beetle	Yes – (USDA 2001)	No records found	No[2] – No evidence of this species being present on mango fruit.	No
Chaetocnema concinnipennis Baly, 1865	Flea beetle	Yes – (USDA 2001)	No records found	No[2] – No evidence of this species being present on mango fruit.	No
Phyllotreta sp.	Flea beetle	Yes – (USDA 2006)	No records found of this species however this genus is present in Australia (AICN 2006)	No[2] – Root (USDA 2006).	No
Anthribidae					
Araecerus suturalis Boheman	Weevil	Yes – (Butani 1993)	No record found	No[2] – No evidence of this species being present on mango fruit.	No
Basitropis nitidicutis Jekel, 1855	Weevil	Yes – (USDA 2001)	No record found	No[2] –No evidence of this species being present on mango fruit.	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Eucorynus crassicornis (Fabricius, 1801)	Weevil	Yes – (USDA 2001)	No record found	No[2]– No evidence of this species being present on mango fruit.	No
Bostrichidae					
Amphicerus anobioides (Waterhouse, 1988)	Stem borer	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Dinoderus distinctus Lesne, 1897	False powder post beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Heterobostrychus aequalis (Waterhouse, 1884)	False powderpost beetle	Yes – (DPP 2001)	Yes – (AICN 2006)		No
Heterobostrychus hamatipennis Lesne, 1895	False powderpost beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Heterobostrychus pileatus Lesne, 1899	False powderpost beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Butani 1993)	No
Lyctoxylon convixtor Lesne, 1936	False powderpost beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Lyctus africanus Lesne, 1907	African powder-post beetle	Yes – (DPP 2001)	No – (PaDIL 2007)	No[2] – Stem (Butani 1993)	No
Lyctus malayanus Lesne	Powder-post beetle	Yes – (USDA 2001)	Yes (PaDIL 2007)		No
Micrapate simplicipennis Lesne, 1895	False powderpost beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Minthea rugicollis (Walker, 1858)	Hairy powderpost beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Parabostrychus elongatus Lesne, 1898	Stem borer	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Schistoceros anobiodes (Waterhouse)	Stem borer	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Sinoxylon anale Lesne, 1897	Auger beetle	Yes – (Butani 1993)	Yes – (AICN 2006)		No
Sinoxylon conigerum Gerstäcker, 1855	Conifer auger beetle	Yes – (DPP 2001)	No records found	No[2] – Branch, leaf, shoot, stem, twig, wood (Filho *et al.* 2006; Ormsby 2006)	No
Sinoxylon crassum Lesne, 1897	Powder post beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Sinoxylon dekhanense Lesne	Powder post beetle	Yes – (DPP, 2001)	No records found	No[2] – Stem (Srivastava, 1997)	No
Sinoxylon indicum Lesne, 1897	Powder post beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Sinoxylon oleare Lesne, 1932	Powder post beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Sinoxylon pygmaeum Lesne	Powder post beetle	Yes – (USDA 2001)	No records found	No[2] – Stem (Butani 1993)	No
Sinoxylon sudanicum Lesne, 1895	Powder post beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Xylodectes ornatus (Lesne, 1897)	Beetle	Yes – (USDA, 2001)	No records found	No[2] – Stem (Butani, 1993)	No
Xylopsocus capucinus (Fabricius, 1781)	False powder-post beetle	Yes – (USDA 2001)	No records found	No[2] – Stem (Butani 1993)	No
Xylothrips flavipes (Illiger, 1801)	Beetle	Yes – (Butani 1993)	Yes – (ANIC 2008)		No
Bruchidae					
Bruchus sp.	Weevil	Yes – (USDA 2001)	Genus is present in Australia (AICN 2006)		No
Buprestidae					
Belionota prasina (Thunberg, 1789)	Mango buprestid	Yes – (DPP 2001)	Yes – (Bellamy 2002)		No
Cerambycidae					

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Acanthophorus serraticornis Olivier	Longicorn beetle; stem borer	Yes – (Butani 1993)	No records found	No[2] – Root, stem (Srivastava 1997)	No
Aeolesthes holosericea Fabricius, 1787	Cherry stem borer	Yes – (DPP 2001)	No records found	No[2] – Bark, stem, wood (Srivastava 1997)	No
Anoplophora versteegii (Ritsema)	Stem borer	Yes – (DPP, 2001)	No	No[2] – Stem (Srivastava, 1997)	No
Batocera numitor (Newman, 1842)	Stem borer	Yes – (Butani 1993; DPP 2001)	No – (Duffy 1968)	No[2] – Stem (Srivastava 1997)	No
Batocera roylei Hope, 1833	Stem borer	Yes – (DPP 2001)	No – (Duffy 1968)	No[2] – Stem (Srivastava 1997)	No
Batocera rubus (Linnaeus, 1758)	Lateral-banded mango longhorn	Yes – (Peña and Mohyuddin 1997; DPP 2001)	No – (Duffy 1968)	No[2] – Branches, trunk (Peña and Mohyuddin 1997); leaf, stem, trunk (Duffy 1968; Peña *et al.* 1998)	No
Batocera rufomaculata (De Geer, 1775)	Mango stem borer	Yes – (DPP 2001; IIE 1994a)	No – (Duffy 1968; IIE 1994a)	No[2] – Bark, branch, root, stem, twig (Srivastava 1997)	No
Batocera titana Thompson, 1859	Stem borer	Yes – (Butani 1993)	No records found	No[2] – Stem (Srivastava 1997)	No
Chlorida festiva (Linnaeus, 1758)	Stem borer	Yes – (USDA 2001)	No	No[2] – Wood (Carrasco 1978)	No
Macrotoma crenata (Fabricius, 1801)	Stem borer	Yes – (Srivastava 1997)	No records found	No[2] – Branch, trunk (Peña and Mohyuddin 1997); stem (Srivastava 1997)	No
Olenecamptus bilobus (Fabricius, 1801)	Round-head borer	Yes – (Srivastava 1997)	Yes – (Storey 1998-2002)		No
Oncideres repandator (Fabricius, 1792)	Beetle	Yes – (DPP 2001)	No – (Breuning 1961)	No[2] – Leaf (Butani 1993)	No
Pseudonemophas versteegii (Ritsema, 1881)	Longicorn beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Sthenias grisator (Fabricius, 1784)	Grapevine girdler; long-horned beetle	Yes – (USDA 2001)	No records found	No[2] – Branch, stem, trunk [of mulberry] (Butani 1978)	No
Stromatium barbatum (Fabricius, 1775)	Kulsi teak borer; longicorn beetle	Yes – (DPP 2001)	No (PaDIL 2007)	No[2] – Branch, stem, trunk (Srivastava 1997)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Xylotrechus smei Laporte & Gory, 1835	Stem borer	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Chrysomelidae					
Aetheomorpha suturata Jacoby	Beetle	Yes – (DPP 2001)	No	No[2] – Leaf (Butani 1993)	No
Altica coerulea (Olivier, 1791)	Flea beetle	Yes – (DPP 2001)	Yes – (APPD 2007)		No
Aulacophora foveicollis (Lucas, 1849)	Red pumpkin beetle	Yes – (DPP 2001)	No records found	No[2] – Leaf (DPP 2001)	No
Clitea picta Baly, 1877	Flea beetle	Yes – (USDA 2001)	No records found	No[2] – Leaf (USDA 2001)	No
Corticarnia gibbosa Herbst	Beetle	Yes – (USDA 2001)	No records found	No[2] – Leaf (USDA 2006)	No
Costalimaita ferruginea (Fabricius, 1801)	Yellow eucalyptus beetle	Yes – (USDA 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Cryptocephalus insubidus Suffrain, 1854	Leaf beetle	Yes – (DPP 2001)	No records found	No[2] – Leaf (Ramamurthy *et al.* 1982)	No
Cryptocephalus suillus Suffrain, 1860	Leaf beetle	Yes – (DPP 2001)	No records found	No[2] – Leaf (Ramamurthy *et al.* 1982)	No
Diapromorpha melanophthalma Lacordaire, 1848	Beetle	Yes – (DPP 2001)	No records found	No[2] – Leaf, stem (DPP 2001)	No
Diapromorpha pallens Olivier, 1808	Beetle	Yes – (Zaman and Maiti 1994)	No records found	No[2] – Leaf, stem (Zaman and Maiti 1994)	No
Diapromorpha suturata Jacoby, 1898	Beetle	Yes – (DPP 2001)	No records found	No[2] – Leaf (DPP 2001)	No
Epepeotes ficicola Fisher	Longicorn beetle; stem borer	Yes – (Butani 1993)	No records found	No[2] – Stem (Srivastava 1997)	No
Epepeotes luscus (Fabricius, 1787)	Longicorn beetle; stem borer	Yes – (Butani 1993)	No records found	No[2] – Stem (Srivastava 1997)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Glenea multiguttata Guérin-Méneville, 1843	Longicorn beetle; stem borer	Yes – (Butani 1993)	No records found	No[2] – Stem (Srivastava 1997)	No
Gynadrophthalma sp.	Beetle	Yes – (USDA 2001)	No known records of this genus occurring in Australia	No[2] – Leaf (USDA 2001)	No
Luperomorpha weisei Jacoby	Flea beetle	Yes – (USDA 2001)	No records found	No[2] – no evidence of this species being present on mango fruit.	No
Monolepta signata Olivier, 1808	Leaf beetle	Yes – (DPP 2001)	No records found	No[2] – Leaf (DPP 2001)	No
Nodostoma dimidiatipes Fiedler, 1943	Beetle	Yes – (USDA 2001)	No records found	No[2] – No evidence of this species being present on mango fruit.	No
Pagria sp.	Leaf beetle	Yes – (USDA 2001)	? – Genus is present in Australia (AICN 2004)	No[2]	No
Pharsalia proxima Gahan, 1890	Longicorn beetle; stem borer	Yes – (Srivastava 1997)	No records found	No[2] – Stem (Srivastava 1997)	No
Plocaederus ferrugineus Linnaeus, 1758	Cashew stem borer	Yes – (USDA 2001)	No records found	No[2] – Branch, root, stem, trunk [of cashew] (Rai 1983)	No
Plocaederus obesus Gahan, 1890	Cashew stem borer; red cocoon-making longhorn	Yes – (Srivastava 1997)	No – (CAB International 2007)	No[2] – Stem (CAB International 2007)	No
Plocaederus pedestris (White, 1853)	Mango bark borer	Yes – (Srivastava 1997)	No – (CAB International 2007)	No[2] – Stem (CAB International 2007); wood (Srivastava 1997)	No
Rhytidodera bowringi White, 1853	Stem borer	Yes – (Srivastava 1997)	No – (Srivastava 1997)	No[2] – Branch, stem (Srivastava 1997)	No
Rhytidodera simulans (White, 1853)	Mango branch borer; mango shoot borer	Yes – (Srivastava 1997)	No records found	No[2] – Stem (Srivastava 1997)	No
Scelodonta strigicollis Motschulsky, 1866	Grapevine flea beetle	Yes – (DPP 2001)	No records found	No[2] – Leaf (DPP 2001)	No
Curculionidae					

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Amblyrhinus poricollis Schoenherr, 1826	Leaf cutter	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Apoderus tranquebaricus Fabricius	Leaf twisting weevil	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Atmetonychus peregrinus (Olivier, 1807)	Weevil	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Camptorrhinus mangiferae Marshall, 1925	Weevil	Yes – (DPP 2001)	Uncertain – genus is present in Australia (Zimmerman 1994b)	No[2] – Leaf (Butani 1993)	No
Crinorrhinus crassirostris Faus	Weevil	Yes – (Patel *et al.* 1997)	No records found	No[2] – Leaf (Patel *et al.* 1997)	No
Deporaus marginatus (Pascoe, 1883)	Mango leaf cutting weevil	Yes – (Peña and Mohyuddin 1997; DPP 2001)	No – (Booth *et al.* 1990)	No[2] – Adults and larvae feed on leaves (Uddin *et al.* 2003); stem (Zaman and Maiti 1994)	No
Desmidophorus hebes Fabricius, 1781	Large black weevil	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Ectatorhinus adamsi Pascoe, 1872	Twig boring weevil	Yes – (Pathak *et al.* 2000)	No	No[2] – (Pathak *et al*. 2000)	No
Hypomeces squamosus (Fabricius, 1792)	Green weevil; gold-dust beetle; gold-dust weevil	Yes – (CAB International 2007)	No – (CAB International 2007)	No[2] – Leaf, root (CAB International 2007)	No
Lepropus lateralis (Fabricius, 1792)	Weevil	Yes – (Zaman and Maiti 1994)	No – (CAB International 2007)	No[2] – Leaf, stem (Zaman and Maiti 1994)	No
Myllocerus dentifer Fabricius, 1792	Weevil	Yes – (Kishun & Chand, 1989)	No records found	No[2]	No
Myllocerus discolor Schoenherr, 1826	Grey weevil	Yes – (Srivastava 1997)	No records found	No[2] – Inflorescence, leaf, shoot (Srivastava 1997)	No
Myllocerus laetivirens Marshall, 1916	Plum ash weevil	Yes – (Srivastava 1997)	No records found	No[2] – Leaf, root (Srivastava 1997)	No
Myllocerus sabulosus Marshall, 1916	Mango leaf weevil	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Myllocerus undecimpustulatus Faust, 1891	Cotton grey weevil; grey weevil	Yes – (DPP 2001)	No – (Booth *et al.* 1990)	No[2] – Leaf (Booth *et al.* 1990; Butani 1993)	No
Peltotrachelus cognatus Marshall, 1917	Weevil	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Peltotrachelus pubes Faust, 1886	Weevil	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Platymycterus sjoestedti Marshall, 1918	Mango leaf weevil	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Rectosternum poricolle (Faust, 1894)	Weevil	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Rhynchaenus mangiferae Marshall, 1915	Mango flea weevil	Yes – (DPP 2001)	No – (Morimoto and Miyakawa 1996)	No[2] – Bud, inflorescence, leaf, shoot (Srivastava 1997); young fruit (Singh and Misra 1981). Although adults were reported feeding on newly-set fruit when population levels were high, adults prefer feeding on panicles and flush growth, both of which desiccate completely as a result. Newly set fruit which are attacked halt development and dry up, removing any fruit-pathway association of this species (Singh and Misra 1981).	No
Sternochetus frigidus (Fabricius, 1787)	Mango pulp weevil	Yes – (DPP 2001)	No – (Booth *et al.* 1990)	Yes – Fruit (Booth *et al.* 1990; Srivastava 1997)	Yes
Sternochetus mangiferae (Fabricius, 1775)	Mango seed weevil	Yes – (DPP 2001)	Yes – Zimmerman 1994b) Under official control in WA	Yes – Fruit, seed (Srivastava 1997; Follett and Gabbard 2000)	Yes (for WA only)
Sternuchopsis frenatus (Faust, 1894)	Weevil	Yes – (DPP 2001)	No – (May 1994)	No[2] – Leaf (Butani 1993); larvae of *Sternuchopsis* feed on plant tissue such as stems and seeds (May 1994)	No
Nitidulidae					
Carpophilus dimidiatus (Fabricius, 1792)	Corn sap beetle	Yes – (DPP 2001)	Yes – (Archibald and Chalmers 1983)		No
Platypodidae					
Crossotarsus externedentatus (Fairmaire, 1849)	Stem borer	Yes – (DPP 2001)	Yes – (Wood and Bright 1992)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Crossotarsus saundersi Chapius, 1865	Stem borer	Yes – (DPP 2001)	No records found	No[2] – Stem (Srivastava 1997)	No
Platypus solidus Walker, 1859	Stem borer	Yes – (DPP 2001)	Yes – (Wood and Bright 1992)		No
Scarabaeidae					
Adoretus bicaudatus Arrow, 1914	Chafer beetle	Yes – (DPP 2001)	No – (Cassis *et al.* 1992, 2002)	No[2] – Leaf (Butani 1993)	No
Adoretus lasiopygus Burmeister, 1855	Grapevine chafer	Yes – (DPP 2001)	No – (Cassis *et al.* 1992, 2002)	No[2] – Leaf (Butani 1993)	No
Anomala dussumieri (Blanchard, 1850)	Chafer beetle	Yes – (DPP 2001)	No – (Cassis *et al.* 1992, 2002)	No[2] – Leaf (Butani 1993)	No
Anomala varicolor (Gyllenhal, 1817)	Chafer beetle	Yes – (DPP 2001)	No – (Cassis *et al.* 1992, 2002)	No[2] – Leaf (Butani 1993)	No
Holotrichia consanguinea Blanchard, 1850	Chafer beetle	Yes – (DPP 2001)	No – (Cassis *et al.* 1992, 2002)	No[2] – Leaf (Butani 1993)	No
Holotrichia insularis Brenske	Chafer beetle	Yes – (Butani 1993)	No records found	No[2] – Root (Butani, 1993)	No
Holotrichia reynaudi Blanchard, 1850	Chafer beetle	Yes – (DPP 2001)	No – (Cassis *et al.* 1992, 2002)	No[2] – Leaf (Butani 1993)	No
Holotrichia serrata (Fabricius, 1787)	Chafer beetle; cock chafer; leaf chafer; May or June beetle; white grub	Yes – (Butani 1993)	No – (CAB International 2007)	No[2] – Leaf, root (CAB International 2007)	No
Popillia sp.	Beetle	Yes – (Bhole *et al.* 1987)	No record found	No[2] – Because of its size and mobility this pest is not expected to stay with the commodity (USDA 2006)	No
Scolytidae					
Hypocryphalus mangiferae (Stebbing, 1914)	Mango bark beetle; shoot gun perforator; shot-hole beetle	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Hypothenemus areccae (Hornung, 1842)	Shot-hole beetle	Yes – (DPP 2001)	No records found	No[2] – Leaf (Butani 1993)	No
Xyleborinus andrewsi (Blandford, 1896)	Ambrosia beetle	Yes – (DPP 2001)	No records found	No[2] – Stem (Butani 1993)	No
Xyleborus affinis Eichhoff, 1868	Ambrosia beetle	Yes – (DPP 2001)	Yes – (Wood and Bright 1992)		No
Xyleborus perforans (Wollaston, 1857)	Island pinhole borer	Yes – (DPP 2001)	Yes – (Wylie *et al.* 1999)		No
Xylosandrus compactus (Eichhoff, 1875)	Chestnut beetle	Yes – (DPP 2001)	No records found	No[2] – Borer of seedlings, shoots and twigs of mango and other hosts in Florida, USA (Ngoan *et al.* 1976)	No
Xylosandrus crassiusculus (Motschulsky, 1866)	Asian ambrosia beetle	Yes – (DPP 2001)	No records found	No[2] – Bark, branch, trunk, twig, wood (Atkinson *et al.* 2000); stem (Butani 1993)	No
Silvanidae					
Oryzaephilus mercator (Fauvel, 1889)	Merchant grain beetle	Yes – (CAB International 2007)	Yes – (AICN 2006)		No
INSECTA: DIPTERA					
Cecidomyiidae					
Allassomyia tenuispatha (Kieffer, 1909)	Gall midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001)	No
Amradiplosis echinogalliperda (Mani, 1947)	Mango leaf gall midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001)	No
Amraemyia allahabadensis (Grover, 1962)	Mango shoot gall midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001)	No
Amraemyia amraemyia Rao, 1950	Psyllid	Yes (USDA 2001)	No record found	No[2] - Immature fruit, inflorescence, leaf. Fruit is only infested at early development stage, becomes pale, hollow and shapeless, and drops prematurely (USDA 2001)	No
Amraemyia brunneigallicola Rao, 1950	Psyllid	Yes (USDA 2001)	No record found	No[2] - Leaf (USDA 2001)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Amraemyia keshopurensis Rao, 1952	Gall midge	Yes – (Srivastava 1997)	No – (Evenhuis 1996)	No2 – Leaf (Srivastava 1997)	No
Amraemyia viridigallicola Rao, 1950	Psyllid	Yes (USDA 2001)	No record found	No[2] - Leaf (USDA 2001)	No
Dasineura amaramanjarae Grover, 1965	Inflorescence gall midge	Yes – (DPP 2000)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001); bud (Peña and Mohyuddin 1997)	No
Dasineura citri Rao and Grover, 1960	Citrus blossom midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001)	No
Erosomyia mangiferae (Felt, 1911)	Mango blossom midge	Yes – (Abbas *et al*. 1989; DPP 2001)	No – (Evenhuis 1996)	No[2] – Bud, shoot, young fruit (CAB International 2007); inflorescence, leaf, stem (Butani 1993)	No
Erosomyia margicola Dastan, 1980	Midge	Yes – (Srivastava 1997)	No – (Evenhuis 1996)	No[2] – Leaf (Srivastava 1997)	No
Gephyraulus indica Grover and Prasad, 1966	Inflorescence gall midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001)	No
Gephyraulus mangiferae (Felt, 1927)	Inflorescence gall midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001)	No
Lasioptera mangiflorae (Grover, 1968)	Blossom midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001)	No
Oligotrophus mangiferae Kieffer, 1909	Mango stem gall midge	Yes – (Butani, 1993)	No – (Evenhuis, 1996)	No2 – Immature fruit, inflorescence, leaf (USDA 2001)	No
Orseolia sp.	Leaf gall midge	Yes – (Anon. 1967)	No – (Evenhuis 1996)	No[2] – Larvae either destroy the mango inflorescence by tunnelling along the axis preventing flowering and fruit set, or attack tender new leaves encircling the inflorescence before dropping to the ground to pupate in the soil (Horticulture World 2004).	No
Procontarina biharana (Gagne, 2004)	Gall midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001)	No
Procontarinia mangiferae (Felt 1911)	Inflorescence gall midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Bud, shoot, young fruit (Grover 1987); inflorescence, leaf, stem (Butani 1993)	No
Procontarinia matteina Kieffer and Cecconi, 1906	Leaf gall midge	Yes – (DPP 2001)	No – (Evenhuis 2006)	No[2] – Immature fruit, inflorescence, leaf (USDA 2001); leaf (Peña and Mohyuddin 1997)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Rhabdophaga mangiferae Mani, 1938	Inflorescence gall midge	Yes – (DPP 2001)	No – (Evenhuis 1996)	No2 – Inflorescence (USDA 2001); leaf, stem (Butani 1993)	No
Tephritidae					
Bactrocera caryeae (Kapoor, 1971)		Yes – (Clarke *et al.* 2005)	No – (Clarke *et al.* 2005)	Yes – Fruit (Peña and Mohyuddin 1997)	Yes
Bactrocera correcta (Bezzi, 1916)	Guava fruit fly	Yes – (DPP 2000; Kumar *et al.* 1994)	No – (White and Elson-Harris 1992)	Yes – Fruit (Peña and Mohyuddin 1997; DPP 2000)	Yes
Bactrocera cucurbitae (Coquillett, 1899)	Melon fruit fly	Yes – (DPP 2000; IIE 1995a)	No – (White and Elson-Harris 1992)	Yes – Fruit (DPP 2000).	Yes
Bactrocera diversa (Coquillett, 1904)	Three striped fruit fly	Yes – (DPP 2001)	No – (Carroll *et al.* 2002 onwards)	No[2, 3] – Although Srivastava (1997) claimed that *B. diversa* attacks mango, the primary reference (Batra 1953) stated that this pest is recorded from various fruit orchards but breeds only in the flowers of cucurbits. Adults survived up to 26 days when an artificial diet of macerated mango was provided (Batra 1953). This pest does not breed in fruit orchards but enters them for shade and shelter (Batra 1964). In captivity trials conducted by Batra (1953) *B. diversa* eggs were laid in cucurbit floral buds but not in fruit or in those of mango and guava. During surveys of various orchards for fruit fly damage to at least seven crop types, Grewel and Kapoor (1986) identified only two out of six fruit fly species, *B. dorsalis* and *B. zonata*, infesting mango fruit. *Bactrocera diversa* was only reared from plums and pears. (This species was previously considered in the 2004 draft with an unrestricted risk rating of high).	No
Bactrocera dorsalis (Hendel, 1912)	Oriental fruit fly	Yes – (DPP 2000; Clarke *et al.* 2005)	No – (Clarke *et al.* 2005)	Yes – Fruit (Srivastava 1997)	Yes
Bactrocera invadens Drew, Tsurata & White, 2005		Yes – (Sithanantham *et al.* 2006)	No – (Drew *et al.* 2005)	Yes – Fruit (Drew *et al.* 2005)	Yes

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Bactrocera tau (Walter, 1909)		Yes – (DPP 2001)	No – (White and Hancock 1997)	Yes. During surveys of various orchards in India for fruit fly damage of at least seven crop types, Grewel and Kapoor (1986) identified only two out of six fruit fly species, *B. dorsalis* and *B. zonata*, infesting mango fruit. *Bactrocera tau* was only reared from pears, along with four other fruit fly species and a suite of other insects. Peña and Mohyuddin (1997) appears to have misquoted that *B. tau* attacks mango fruit. Narayanan and Batra (1960) concluded that similarities between *B. tau* and *B. cucurbitae* had probably resulted in confusion between biology. Questionable association with fruit but included for further consideration.	Yes
Bactrocera zonata (Saunders, 1841)	Peach fruit fly	Yes – (DPP 2000; Srivastava 1997)	No – (IIE 1996b)	Yes – Fruit (Peña and Mohyuddin 1997; Srivastava 1997; DPP 2000)	Yes
Carpomyia vesuviana Costa, 1854	Ber fruit fly	Yes – (Grewal and Kapoor 1986)	No – (Evenhuis 1996)	No[2] – This species is monophagous on Jujube (Grewal and Kapoor 1986).	No
INSECTA: HEMIPTERA					
Aleyrodidae					
Aleurocanthus mangiferae Quaintance & Baker, 1917	Mango blackfly	Yes – (DPP 2000)	No – (Martin 1999)	No[2] – Leaf, shoot (DPP 2000)	No
Aleurocanthus woglumi Ashby, 1915	Citrus blackfly	Yes – (Butani 1993; IIE 1995a)	No – (Martin 1999)	No[2] – Leaf (CAB International 2007)	No
Aleurodicus dispersus Russell, 1965	Spiralling whitefly; coconut whitefly	Yes – (CAB International 2007)	Yes – (Martin 1999)		No
Aleurothrixus floccosus (Maskell, 1895)	Citrus whitefly; flocculent whitefly; woolly whitefly	Yes – (CAB International 2007)	No – (Martin 1999)	No[2] – Leaf (CAB International 2007)	No
Rhachisphora rutherfordi (Quaintance & Baker)	Whitefly	Yes – (David and Regu 1991)	No – (Martin 1999)	No[2] – Leaf (David and Regu 1991)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Aphrophoridae					
Clovia sp.	Spittlebug	Yes – (Dalvi *et al.* 1992)	No – (Fletcher 2003)	No[2] – No evidence of this genus being present on mango fruit. Spittlebug nymphs are often surrounded by a mass of foam (spittle) for protection and suck sap usually from new plant shoots; adults take evasive action when disturbed (Liang and Fletcher 2003).	No
Aphidae					
Aphis epillabina Kulkarny	Aphid	Yes - (USDA 2001)	No records found	No[2] – Inflorescence, leaf, stem (Butani 1993)	No
Aphis gossypii Glover, 1877	Cotton aphid	Yes – (DPP 2001)	Yes – (AICN 2006)		No
Aphis praeterita Walker, 1849	Aphid	Yes – (DPP 2001)	No records found	No[2] – Inflorescence, leaf, stem (Butani 1993)	No
Greenidea mangiferae Takahashi, 1925	Aphid	Yes – (DPP 2001)	No records found	No[2] – Inflorescence, leaf, stem (DPP 2001)	No
Macrosiphum euphorbiae (Thomas, 1878)	Potato aphid	Yes – (DPP 2001)	Yes – (Hely *et al.* 1982; Dillard *et al.* 1993; Berlandier 1997)		No
Toxoptera aurantii Boyer de Fonscolombe, 1841	Black tea aphid	Yes – (DPP 2001)	Yes – (Hely *et al.* 1982; Carver 1984)		No
Toxoptera odinae (van der Goot, 1917)	Mango aphid	Yes – (DPP 2001)	No records found	No[2] – Inflorescence, leaf, shoot (Srivastava 1997); stem (Butani 1993)	No
Cicadellidae					
Amrasca splendens Ghauri, 1967	Mango leaf hopper; mango jassid	Yes – (Srivastava 1997)	No – (CAB International 2007)	No[2] – Flower, leaf (Dalvi and Dumbre 1994)	No
Amritodus atkinsoni Lethierry, 1889	Mango hopper	Yes – (DPP 2000)	No – (Tandon 1998)	No[2] – Inflorescence, leaf, shoot (Srivastava 1997); leaf (Peña and Mohyuddin 1997)	No
Amritodus brevistylus Viraktamath, 1976	Mango leafhopper	Yes – (Viraktamath 1976)	No – (Fletcher 2003)	No[2] – Inflorescence, leaf (USDA 2001)	No
Busoniomimus manjunathi Viraktamath & Viraktamath, 1985	Mango hopper	Yes – (Viraktamath and Viraktamath 1985)	No – (Fletcher 2003)	No[2] – Inflorescence, leaf, shoot (Srivastava 1997)	No
Idioscopus anasuyae Viraktamath & Viraktamath, 1985	Mango hopper	Yes – (Viraktamath and Viraktamath 1985)	No records found	No[2] – Inflorescence, leaf (USDA 2001)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Idioscopus clypealis (Lethierry, 1889)	Mango leafhopper	Yes – (DPP 2001)	Yes – (Fletcher 2000)		No
Idioscopus decoratus Viraktamath, 1976	Leafhopper	Yes – (Viraktamath 1976)	No – (Fletcher 2000)	No[2] – Inflorescence, leaf (USDA 2001)	No
Idioscopus fasciolatus (Distant, 1908)	Leafhopper	Yes – (Srivastava 1997)	No – (Fletcher 2000)	No[2] – Inflorescence, leaf, shoot (Srivastava 1997)	No
Idioscopus incertus (Baker, 1924)	Leafhopper	Yes – (Srivastava 1997)	No – (Fletcher 2000)	No[2] – Inflorescence, leaf, shoot (Srivastava 1997)	No
Idioscopus jayashriae Viraktamath & Viraktamath, 1985	Mango hopper	Yes – (Viraktamath and Viraktamath 1985)	No – (Fletcher 2000)	No[2] – Inflorescence, leaf, shoot (Srivastava 1997)	No
Idioscopus nagpurensis Pruthi, 1930	Mango leafhopper	Yes – (Dalvi *et al.* 1992)	No – (CAB International 2007)	No[2] – Flower, leaf (Dalvi and Dumbre 1994) Affects fruit setting (CAB International 2007).	No
Idioscopus nitidulus (Walker, 1870)	Mango brown leafhopper	Yes – (DPP 2001)	Yes – (Fletcher 2000)		No
Idioscopus scutellatus (Distant, 1908)	Leafhopper	Yes – (Srivastava 1997)	No – (Fletcher 2000)	No[2] – Inflorescence, leaf, shoot (Srivastava 1997)	No
Idioscopus shillongensis Viraktamath, 1976	Leafhopper	Yes – (Viraktamath 1976)	No – (Fletcher 2000)	No[2] – No evidence of this species being present on mango fruit.	No
Idioscopus spectabilis Viraktamath, 1976	Leafhopper	Yes – (Rajak 1986)	No – (Fletcher 2000)	No[2] – Leaf (USDA 2001)	No
Cixiidae					
Oliarus sp.	Mango hopper	Yes – (Dalvi *et al.* 1992)	No – (Fletcher 2003)	No[2] – No evidence of this species being present on mango fruit. Other Indian cixiid species attack the leaves of mango (Peña and Mohyuddin 1997); North American *Oliarus* spp. are suspected of being root feeders (University of Minnesota 2000); New Zealand cixiids lay their eggs in the soil, nymphs develop around and feed on plant roots (Larivière 1999).	No
Coccidae					

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Ceroplastes actiniformis Green, 1896	Soft scale	Yes – (Srivastava 1997)	No – (Ben-Dov 1993)	No[2, 3] – No evidence of this species being present on mango fruit. On leaf (Srivastava 1997; USDA 2006). (This species was previously considered in the 2004 Draft with an unrestricted risk rating of low).	No
Ceroplastes ceriferus (Fabricius, 1798)	Indian wax scale; Indian white wax scale; Japanese wax scale	Yes – (Butani 1993)	Yes – (CAB International 2007)		No
Ceroplastes floridensis Comstock, 1881	Florida wax scale	Yes – (Srivastava 1997)	Yes – (CAB International 2007)		No
Ceroplastes pseudoceriferus Green, 1935	Ceriferous wax scale; horned wax scale	Yes – (Butani 1993)	No – (Ben-Dov 1993)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997); leaf (USDA 2001)	No
Ceroplastes rubens Maskell, 1893	Pink wax scale	Yes – (Srivastava 1997)	Yes – (Qin and Gullan 1994; Johnson and Parr 1999)		No
Ceroplastes rusci (Linnaeus, 1758)	Fig wax scale	Yes – (IIE 1993a)	Yes – (AICN 2006)		No
Coccus almoraensis Avasthi & Shafee, 1984	Soft scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf, stem (USDA 2006)	No
Coccus colemani Kannan, 1918	Soft scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf, stem (USDA 2006)	No
Coccus discrepans (Green, 1904)	Soft scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf, stem (USDA 2001)	No
Coccus hesperidum Linnaeus, 1758	Brown soft scale; common shield scale; soft brown scale	Yes – (Butani 1993)	Yes – (CAB International 2007)		No
Coccus kosztarabi Avasthi & Shafee, 1984	Soft scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf, stem (USDA 2006)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Coccus latioperculatum (Green, 1922)	Soft scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (USDA 2001)	No
Coccus longulus (Douglas, 1887)	Long soft scale	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006; DAWA 2004) This species was previously considered further for WA only (DAFF 2004). The presence of this species in WA has since been confirmed (DAWA 2004).		No
Coccus viridis (Green, 1889)	Green coffee scale	Yes – (Srivastava 1997)	Yes – (Smith *et al.* 1997)		No
Eucalymnatus tessellatus (Signoret, 1873)	Palm scale	Yes – (Butani 1993)	Yes – (Ben-Dov *et al.* 2006)		No
Kilifia acuminata (Signoret, 1873)	Acuminate scale	Yes – (Srivastava 1997)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (Peña and Mohyuddin 1997); stem (USDA 2001)	No
Leptocorisa acuta (Thunberg, 1783)	Paddy bug	Yes – (CAB International 2007)	Yes – (AICN 2006)		No
Maacoccus bicruciatus (Green, 1904)	Soft scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (USDA 2001)	No
Maacoccus piperis namunakuli (Green, 1922)	Soft scale	Yes – (DPP 2001)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (DPP 2001)	No
Milviscutulus mangiferae (Green, 1889)	Mango shield scale	Yes – (Butani 1993)	Yes[4] – (ANIC 2008) Previously considered for WA only (DAFF 2004).		No
Neoplatylecanium adersi (Newstead, 1917)	Soft scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Paralecanium expansum (Green, 1896)	Flat scale	Yes – (DPP 2001)	Yes – (Ben-Dov *et al.* 2006)		No
Parasaissetia nigra (Nietner, 1861)	Nigra scale	Yes – (CAB International 2007)	Yes – (CABI/EPPO 1997b)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Parthenolecanium persicae (Fabricius, 1776)	European peach scale	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006)		No
Prococcus acutissimus (Green, 1896)	Banana-shaped scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (Peña and Mohyuddin 1997)	No
Pulvinaria avasthii Yousuf & Shafee, 1988	Pulvinaria scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Pulvinaria iceryi (Signoret, 1869)	Pulvinaria scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Pulvinaria ixorae Green, 1909	Pulvinaria scale	Yes – (Butani 1993)	No – (Ben-Dov 1993)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Pulvinaria polygonata Cockerell, 1905	Cottony citrus scale	Yes – (Gupta and Singh 1988a)	Yes – (Smith *et al.* 1997)		No
Pulvinaria psidii Maskell, 1893	Green shield scale	Yes – (Butani 1993)	Yes – (CAB International 2007).		No
Saissetia coffeae (Walker, 1852)	Hemispherical scale	Yes – (Butani 1993)	Yes – (CAB International 2007)		No
Saissetia miranda (Cockerell & Parrott, 1899)	Mexican black scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf, stem (USDA 2001)	No
Saissetia oleae (Olivier, 1791)	Black scale	Yes – (Ben-Dov *et al.* 2006)	Yes – (CAB International 2007)		No
Saissetia privigna De Lotto, 1965	Soft scale	Yes – (Srivastava 1997)	No – (Ben-Dov *et al*. 2001)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Taiwansaissetia formicarii (Green, 1896)	Soft scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (USDA 2001)	No
Vinsonia stellifera (Westwood, 1871)	Stellate scale	Yes – (Srivastava 1997)	Yes – (Qin and Gullan 1994)		No
Coreidae					

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Acanthocoris scabrator (Fabricius, 1803)	Coreid bug; squash bug	Yes – (Koshy *et al.* 1977)	No – (CAB International 2007)	No[2, 3] – Branch, young or unripe fruit, leaf, stem (CAB International 2007); inflorescence (DPP 2001). It is considered very unlikely that this species would be present on the importation pathway because of its large size and highly mobile behaviour, and because it only feeds externally on young or unripe fruit. (This species was previously considered in the 2004 Draft with an unrestricted risk rating of negligible).	No
Diaspididae					
Abgrallaspis cyanophylli (Signoret, 1869)	Cyanophyllum scale	Yes – (Srivastava 1997)	No – (Ben-Dov *et al.* 2006)	Yes – Fruit, leaf, stem (Srivastava 1997); bark (Kessing and Mau 1993)	Yes
Aonidiella aurantii (Maskell, 1879)	California red scale	Yes – (Srivastava 1997)	Yes – (IIE 1996a)		No
Aonidiella citrina (Craw, 1890)	Citrus yellow scale	Yes – (Butani 1993)	Yes – (OEPP/EPPO 2005b)		No
Aonidiella inornata McKenzie, 1938	Armoured scale; hard scale	Yes – (Gupta and Singh 1988a)	Yes – (Ben-Dov *et al.* 2006) Not in WA (DAWA 2006)	No[2] – Leaf (Gupta and Singh 1988a) USDA (2001) states that pest infests "whole plant", but that it is unlikely to follow the fresh fruit pathway.	No
Aonidiella orientalis (Newstead, 1894)	Oriental red scale	Yes – (Srivastava 1997)	Yes – (CAB International 2007).		No
Aspidiotus destructor Signoret, 1869	Coconut scale	Yes – (Gupta and Singh 1988a)	Yes – (CIE 1966a)		No
Aspidiotus nerii Bouché, 1833	Oleander scale	Yes – (Butani 1993)	Yes – (Hely *et al.* 1982; DAWA 2004) This species was previously considered further (for WA only) (DAFF 2004). The presence of this species in WA has since been confirmed (DAWA 2004).		No
Aulacaspis martini Williams & Watson, 1988	Armoured scale	Yes – (DPP 2001)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (DPP 2001)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Aulacaspis rosae (Bouché, 1833)	Mango snow scale	Yes – (Butani 1993)	Yes – (Ben-Dov *et al.* 2006)		No
Aulacaspis tubercularis Newstead, 1906a	Mango scale	Yes – (Butani 1993)	Yes – (Cunningham 1989; Johnson and Parr 1999)		No
Aulacaspis vitis (Green, 1896)	Armoured scale; hard scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (DPP 2001)	No
Chrysomphalus aonidum (Linnaeus, 1758)	Black scale	Yes – (Butani 1993)	Yes – (Ben-Dov *et al.* 2006)		No
Chrysomphalus dictyospermi (Morgan, 1889)	Spanish red scale	Yes – (Butani 1993)	Yes – (CAB International 2007)		No
Chrysomphalus pinnulifer (Maskell, 1891)	Armoured scale; hard scale	Yes – (USDA 2001)	No records found	No[2] – Stem (USDA 2001)	No
Fiorinia fioriniae (Targioni Tozzetti, 1867)]	Avocado scale; camellia scale; European fiorinia scale; fiorinia scale; palm fiorinia scale; ridged scale	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006)		No
Hemiberlesia lataniae (Signoret, 1869)	Latania scale	Yes – (Srivastava 1997)	Yes – (Ben-Dov *et al.* 2006; AICN 2006)		No
Hemiberlesia rapax (Comstock, 1881)	Greedy scale	Yes – (Butani 1993)	Yes – (DAWA 2004) This species was previously considered further for WA only (DAFF 2004). The presence of this species in WA has since been confirmed (DAWA 2004).		No
Ischnaspis longirostris (Signoret, 1882a)	Black thread scale	Yes – (DPP 2001)	Yes – (Ben-Dov *et al.* 2006)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Lepidosaphes beckii (Newman, 1869)	Mussel scale	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006; DAWA 2004) This species was previously considered further for WA only (DAFF 2004). The presence of this species in WA has since been confirmed (DAWA 2004).		No
Lepidosaphes gloverii (Packard, 1869)	Glover's scale	Yes – (Butani 1993)	Yes – (Ben-Dov *et al.* 2006). This species was previously considered further for WA only (DAFF 2004). However as no specific measures are currently in place to prevent the entry of this species into WA from other states in Australia where it is present it does not meet the definition of a quarantine pest and is not considered further in this report.		No
Lepidosaphes mcgregori Banks, 1906	McGregor scale	Yes – (Srivastava 1997)	No – (Ben-Dov *et al.* 2006)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Lepidosaphes pallidula (Williams, 1969)	Armoured scale; hard scale	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006)		No
Lepidosaphes shikohabadensis Dutta, 1990	Armoured scale; hard scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Lepidosaphes tapleyi Williams, 1960	Guava long scale; oyster scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf, stem (USDA 2001)	No
Lindingaspis ferrisi McKenzie, 1950	Armoured scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (Peña and Mohyuddin 1997).	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Lindingaspis floridana Ferris, 1942	Armoured scale; hard scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (Peña and Mohyuddin 1997)	No
Lindingaspis greeni (Brain & Kelly)	Armoured scale; hard scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Stem (USDA 2001)	No
Lindingaspis rossi (Maskell, 1891)	Circular black scale	Yes – (Butani 1993)	Yes – (Ben-Dov *et al.* 2006)		No
Mangaspis bangalorensis Takagi & Kondo, 1997	Armoured scale	Yes – (Takagi *et al*. 1997)	No records found	No2 – Bud, leaf, twig (Takagi *et al*. 1997)	No
Morganella longispina (Morgan, 1889)	Maskell scale; plumose scale	Yes – (Srivastava, 1997)	No – (CAB International, 2003)	No2 – Branch, bud, leaf, trunk (Peña and Mohyuddin 1997)	No
Mycetaspis personata (Comstock)	Masked scale	Yes – (Srivastava 1997)	No – (CAB International 2007)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Parlatoria camelliae Comstock, 1883	Camellia parlatoria scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf (Peña and Mohyuddin 1997)	No
Parlatoria cinerea Hadden, 1909	Apple parlatoria	Yes – (Butani 1993)	No – (Ben-Dov *et al*. 2006)	No[2] – Leaf (Peña and Mohyuddin 1997)	No
Parlatoria crypta (McKenzie, 1943)	Mango white scale	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	Yes – Considered a pest of quarantine significance by the USA that could be introduced via mango fruit (NARA 2006). This species has been recorded in UK on consignments of mango fruit from Pakistan (DEFRA 2008)	Yes
Parlatoria oleae (Colvée, 1880)	Olive scale	Yes – (Butani 1993)	Yes – (Ben-Dov *et al*. 2006)		No
Parlatoria pergandii Comstock, 1881	Chaff scale	Yes – (Butani 1993)	Yes – (CAB International 2007)		No
Parlatoria pseudaspidiotus Lindinger, 1905	Vanda orchid scale; vanda scale	Yes – (Butani 1993)	No – (Ben-Dov *et al*. 2006)	No[2] – Leaf (Peña and Mohyuddin 1997)	No
Pinnaspis aspidistrae (Signoret, 1869)	Aspidistra scale	Yes – (Butani 1993)	Yes – (Ben-Dov *et al.* 2006)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Pinnaspis strachani (Cooley, 1899)	Cotton white scale	Yes – (Srivastava 1997)	Yes – (Ben-Dov *et al.* 2006)		No
Pseudaonidia trilobitiformis (Green, 1896)	Gingging scale	Yes – (Watson 2007)	Yes – (Watson 2007)		No
Pseudaulacaspis barberi (Green, 1908)	Armoured scale; hard scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Pseudaulacaspis cockerelli (Cooley, 1897)	False oleander scale	Yes – (Butani 1993)	Yes – (Johnson and Parr 1999; Rosen and DeBach 1986)		No
Pseudaulacaspis pentagona (Targioni Tozzetti, 1886)	Mulberry scale	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006)		No
Radionaspis indica (Marlatt, 1908)	Mango scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997); branch, bud, leaf, trunk (Peña and Mohyuddin 1997)	No
Semilaspidus mangiferae Takahashi	Armoured scale	Yes – (Butani 1993)	No records found	No[2] – Stem (USDA 2001)	No
Dictyopharidae					
Dictyophara sp.	Mango hopper	Yes – (Dalvi *et al.* 1992)	? – Genus is present in Australia (Fletcher 2003)	No[2] – Species in this genus are commonly collected from grass (Fletcher and Larivière 2002).	No
Flatidae					
Flata spp.	Mango hopper	Yes – (Dalvi *et al.* 1992)	No – (Fletcher 2003)	No[2] – No evidence of this species being present on mango fruit. The eggs of species in this family are laid on stems or leaves; nymphs prefer to feed on leaves and stems; adults take evasive action when disturbed (Mau & Kessing 1993).	No
Ketumala sp.	Mango hopper	Yes – (Davli *et al.* 1992)	No – (Fletcher 2003)	No[2] – No evidence of this species being present on mango fruit. The eggs of species in this family are laid on stems or leaves; nymphs prefer to feed on leaves and stems; adults take evasive action when disturbed (Mau & Kessing 1993).	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Salurnis marginellus Guérin-Méneville	Mango hopper	Yes – (Davli *et al.* 1992)	No – (Fletcher 2003)	No[2] – Inflorescence (Davli *et al.* 1992)	No
Kerridae					
Kerria lacca (Kerr, 1782)	Lac insect	Yes – (Srivastava 1997)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf, stem, twig (Butani and Lele 1976)	No
Paratachardina theae Green, 1907	Scale insect	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2] – Bark, flower, root, stem, twig (Srivastava 1997)	No
Lecanodiaspididae					
Psoraleococcus sp. nr. *multipori* (Morrison)	Pit scale	Yes – (Bhumannavar and Jacob 1989)	No records found	No[2] – Branch, leaf, stem (Bhumannavar and Jacob 1989)	No
Lophopidae					
Pyrilla perpusilla Walker, 1851	Sugarcane leafhopper; sugarcane plant hopper; Indian sugarcane pyrilla	Yes – (USDA 2001)	No – (CAB International 2007)	No[2] – Bark (Dubey *et al.* 1981); leaf (CAB International 2007)	No
Lygaeidae					
Spilostethus pandurus (Scopoli, 1763)	Indian milkweed bug	Yes – (DPP 2001)	No record found	No[3] – This species was previously considered in the 2004 Draft with an unrestricted risk rating of negligible Associated with mango fruit in India (DPP 2001), but Butani (1993) notes that once fruit is attacked by this species it rapidly deteriorates and drops prematurely. Furthermore, it is considered very unlikely that this species would be present on the importation pathway because of its large size and highly mobile behaviour, and because it only feeds externally on the fruit.	No
Margarodidae					

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Drosicha contrahens Walker, 1958	Mango mealybug	Yes – (DPP 2001)	No – (Ben-Dov *et al.* 2006)	No[2, 3] – This species was previously considered to be present on pathway (DAFF 2004). No information found on this species attacking mango fruit.	No
Drosicha dalbergiae (Stebbing, 1903)	Mealybug	Yes – (DPP 2001)	No record found	No[2, 3] – This species was previously considered to be present on pathway (DAFF 2004). No information found on this species attacking mango fruit.	No
Drosicha mangiferae (Stebbing, 1902)	Giant mealybug	Yes – (DPP 2000)	No – (Tandon 1998)	No[2] – Fruit peduncle (Tandon 1998); inflorescence, shoot (Srivastava 1997); leaf, stem (Butani 1993). Affects fruit set and causes fruit drop (Tandon 1998)	No
Drosicha stebbingii (Stebbing, 1902)	Mango mealybug	Yes – (DPP 2000)	No – (Tandon 1998)	No[2] – Fruit peduncle, inflorescence, leaf, shoot (Tandon 1998). Affects fruit set and causes fruit drop (Tandon 1998)	No
Icerya aegyptiaca (Douglas, 1890)	Egyptian fluted scale; Egyptian mealybug; breadfruit mealybug; giant mealybug	Yes – (CAB International 2007)	Yes – (CIE 1966b)		No
Icerya minor Green, 1908	Fluted scale	Yes – (Butani 1993)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf, shoot, stem (USDA 2001)	No
Icerya pulchra (Leonardi, 1907)	Fluted scale	Yes – (Butani 1993)	No – (CAB International 2007)	No[2] – Leaf, shoot, stem (USDA 2001)	No
Icerya purchasi Maskell, 1879	Cottony cushion scale; Australian bug; mealy scale; white scale	Yes – (Srivastava 1997)	Yes – (CIE 1971)		No
Icerya seychellarum (Westwood, 1855)	Seychelles scale; Okada cottony-cushion scale; silvery cushion scale	Yes – (CAB International 2007)	Yes – (CAB International 2007)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Labioproctus poleii (Green, 1922)	Mealybug	Yes – (DPP 2001)	No – (Ben-Dov *et al.* 2006)	No[2] – Leaf, stem (Ghose 1963)	No
Perissopneumon ferox Newstead, 1900	Mealybug	Yes – (Srivastava 1997)	No – CAB International 2007)	Yes – Fruit stalk, inflorescence and fruit (Srivastava 1997)	Yes
Membracidae					
Leptocentrus obliquis Walker	Tree hopper	Yes – (DPP 2001)	No records found	No[2] – Leaf, stem (Butani 1993)	No
Otinotus oneratus (Walker, 1858)	Cow bug	Yes – (DPP 2001)	No records found	No[2] – Leaf, stem (DPP 2001)	No
Oxyrhachis serratus Ahmad & Abrar	Bug	Yes – (USDA, 2001)	No	No[2] – Leaf, stem (USDA, 2001)	No
Oxyrhachis tarandus Fabricius, 1798	Tree hopper	Yes – (DPP 2001)	No records found	No[2] – Leaf, stem (Butani 1993)	No
Tricentrus bicolor Distant	Common tree hopper	Yes – (DPP 2001)	No records found	No[2] – Leaf, stem (Butani 1993)	No
Pentatomidae					
Antestiopsis cruciata (Fabricius, 1775)	Indian coffee bug	Yes – (DPP 2001)	No records found	No[3] – Associated with mango fruit in India (DPP 2001), but Butani (1993) notes that once fruit is attacked by this species it rapidly deteriorates and drops prematurely.	No
Bagrada hilaris (Burmeister, 1835)	Painted bug	Yes – (DPP 2001; Butani 1993)	No – (DAWA 2005)	No[2, 3] – This species was previously considered to be present on pathway (DAFF 2004). No evidence of this species attacking mango fruit in India. USDA (2006) stated that it was only on mango stem and leaf, not on fresh fruit pathway	No
Chrysocoris patricius (Fabricius, 1798)	Bug	Yes – (Kishun and Chand 1989)	No records found	No[3] – Fruit, inflorescence, leaf, stem (DPP 2001). However, it is considered very unlikely that this species would be present on the importation pathway as it only feeds externally on the fruit and because of its large size and highly mobile behaviour.	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Halys dentata (Fabricius, 1775)	Bark bug	Yes – (DPP 2001)	No records found	No[3] – Fruit, inflorescence, leaf, stem (DPP 2001). However, it is considered very unlikely that this species would be present on the importation pathway as it only feeds externally on the fruit and because of its large size and highly mobile behaviour.	No
Nezara viridula (Linnaeus, 1758)	Green vegetable bug	Yes – (DPP 2001)	Yes – (Waterhouse 1998)		No
Plataspidae					
Coptosoma nazirae Atkinson, 1888	Dwarf shield bug	Yes – (DPP 2001)	No records found	No[3] – Fruit, inflorescence, leaf, stem (DPP 2001). However, it is considered very unlikely that this species would be present on the importation pathway as it only feeds externally on the fruit and because of its large size and highly mobile behaviour.	No
Pseudococcidae					
Dysmicoccus brevipes (Cockerell, 1893n)	Pineapple mealybug	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006)		No
Ferrisia malvastra (McDaniel, 1962)	Malvastrum mealybug	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006)	Yes – Ben-Dov *et al.* (2006) does not list mango as a host, but confusion over species identification means that older references to *F. virgata* on mango may actually be referring to *F. malvastra.*	Yes
Ferrisia virgata (Cockerell, 1893j)	Striped mealybug	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006)	Yes – Fruit, leaf, shoot, stem (APPD 2007).	Yes
Formicoccus robustus (Ezzat & McConnell, 1956)	Mango root mealybug	Yes – (USDA 2001)	No – (Ben-Dov *et al.* 2006)	No[2] – Root (Puttarudriah and Eswaramurthy 1976)	No
Geococcus coffeae Green, 1933	Coffee root mealybug	Yes – (Ben-Dov *et al.* 2006)	Yes – (Williams 1985)		No
Maconellicoccus hirsutus (Green, 1908)	Pink hibiscus mealybug	Yes – (Ben-Dov *et al.* 2006)	Yes – (Goolsby *et al* 2002)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Nipaecoccus nipae (Maskell, 1893b)	Coconut mealybug	Yes – (Ben-Dov *et al.* 2006)	No – (Ben-Dov *et al.* 2006)	No[2, 3] – This species was previously considered to be present on pathway (DAFF 2004). No information on this species attacking mango fruit (Butani 1993; Srivastava 1997; Ben-Dov *et al.* 2006).	No
Nipaecoccus viridis (Newstead, 1894)	Spherical mealybug; coffee mealybug;	Yes – (Srivastava 1997)	Yes – (Williams 1985)	No[2] – Leaf, stem, twig (CAB International 2007)	No
Planococcoides sp. nr. *robustus* Ezzat & McConnell, 1956	Mango root mealybug	Yes – (USDA 2001)	No – (Ben-Dov *et al*. 2001)	No[2] – Root (Puttarudriah and Eswaramurthy 1976)	No
Planococcus citri (Risso, 1813)	Citrus mealybug	Yes – (Srivastava 1997)	Yes – (AICN 2006)		No
Planococcus ficus (Signoret, 1875)	Grapevine mealybug;	Yes – (DPP 2001)	No – (Ben-Dov *et al.* 2006)	No[2, 3] – No evidence of this species attacking mango fruit. This species was previously considered to be present on pathway (DAFF 2004).	Yes
Planococcus lilacinus (Cockerell, 1905)	Coffee mealybug	Yes – (Mani 1995)	No – (Ben-Dov *et al.* 2006)	Yes – Fruit, inflorescence, leaf, stem, whole plant (Entwhistle 1972).	Yes
Planococcus minor (Maskell, 1897)	Pacific mealybug	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006)	No[2] – This species was previously considered to be present on pathway and considered further for WA (DAFF 2004)	No
Pseudococcus longispinus (Targioni Tozzetti, 1867)	Long-tailed mealybug	Yes – (Ben-Dov *et al.* 2006)	Yes – (Ben-Dov *et al.* 2006)		No
Rastrococcus iceryoides (Green, 1908)	Downy snowline mealybug	Yes – (Srivastava 1997)	No – (Ben-Dov *et al.* 2006)	Yes – Fruit, leaf, twig (Srivastava 1997); inflorescence, shoot (CAB International 2007); stem (DPP 2001)	Yes
Rastrococcus invadens Williams, 1986	Mango mealybug	Yes – (Narasimham and Chacko 1991)	No – (Ben-Dov *et al.* 2006)	Yes – Bud, fruit, leaf (Peña and Mohyuddin 1997); twig (Narasimham and Chacko 1991)	Yes
Rastrococcus mangiferae (Green, 1896)	Mango mealybug	Yes – (Srivastava 1997)	No – (Williams 1985)	No[2] – Leaf, stem (DPP 2001)	No
Rastrococcus spinosus (Robinson, 1918)	Philippine mango mealybug	Yes – (USDA 2001)	No – (Ben-Dov *et al.* 2006)	Yes – Bud, fruit, leaf (Peña and Mohyuddin 1997)	Yes

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Psyllidae					
Apsylla cistellata (Buckton, 1892)	Mango shoot gall psylla	Yes – (DPP 2000)	No records found	No[2] – Bud, leaf, shoot, twig (Srivastava 1997); inflorescence (Peña and Mohyuddin 1997)	No
Arytania obscura Crawford	Psyllid	Yes – (Butani 1993)	No records found	No[2] – Leaf, stem (USDA 2001)	No
Calophya brevicornis (Crawford, 1919)	Gall psyllid; mango shoot gall psylla	Yes – (Srivastava 1997)	No – (Burckhardt and Basset 2000)	No[2] – Leaf, stem (Srivastava 1997)	No
Calophya maculata (Mathur, 1975)	Mango hopper	Yes – (Dalvi *et al.* 1992)	No – (Burckhardt and Basset 2000)	No[2] – Leaf (USDA 2001)	No
Calophya nigra Kuwayama, 1908	Mango psyllid	Yes – (Davli *et al.* 1992)	No – (Burckhardt and Basset 2000)	No[2] – Leaf (Peña and Mohyuddin 1997)	No
Leuronota minuta (Crawford, 1912)	Psyllid	Yes – (Butani 1993)	No records found	No[2] – Stem, leaf (USDA 2001)	No
Trioza jambolanae Crawford, 1917	Psyllid	Yes – (DPP 2001)	No records found	No[2] – Leaf (USDA 2001)	No
Pyrrhocoridae					
Dysdercus koenigii (Fabricius, 1775)	Red cotton bug	Yes – (DPP 2001)	No records found	No[3] – Although this species is occasionally known to feed on mango fruit (Butani 1993; DPP 2001). It is considered very unlikely that this species would be present on the importation pathway because of its large size and highly mobile behaviour, and because it only feeds externally on the fruit. (This species was previously considered in the 2004 draft with an unrestricted risk rating of negligible.)	No
Ricaniidae					
Privesa sp.	Mango hopper	Yes – (Davli *et al.* 1992)	Unknown – Genus is present in Australia (Fletcher 2003)	No[2] – No evidence of species in this genus being present on mango fruit. Adults and nymphs of species in this family are usually found together on the under surfaces of leaves or along stems (Fletcher 1979).	No
Ricania marginalis Walker, 1851	Mango hopper	Yes – (Davli *et al.* 1992)	No – (Fletcher 2003)	No[2] – Inflorescence (USDA 2001)	No
INSECTA: HYMENOPTERA					

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Formicidae					
Anoplolepis gracilipes (Smith, 1857)	Crazy ant; long legged ant	Yes – (Srivastava 1997)	Yes – (Shattuck and Barnett 2001)		No
Azteca schimperi Emery, 1893	Ant	Yes – (Srivastava 1997)	No – (Shattuck and Barnett 2001)	No[2] – Builds nest in foliage (Srivastava 1997)	No
Camponotus compressus (Fabricius, 1787)	Ant	Yes – (Kishin and Chand, 1989)	No – (Shattuck and Barnett, 2001)	No[2]	No
Camponotus sericeus (Fabricius, 1798)	Ant	Yes – (Kishin and Chand, 1989)	No – (Shattuck and Barnett, 2001)	No[2]	No
Dorylus orientalis Westwood, 1835	Oriental army ant; brown ant; red ant	Yes – (Menon and Srivastava 1976)	No – (Shattuck and Barnett 2001)	No[2] – Builds nest in foliage (Srivastava 1997)	No
Oecophylla longinoda (Latreille, 1802)	Maji moto ant; weaver ant	Yes – (Butani 1993)	No – (Shattuck and Barnett 2001)	No[2] – Builds nest in foliage (Srivastava 1997)	No
Oecophylla smaragdina (Fabricius, 1775)	Green ant; red tree ant	Yes – (DPP 2000)	Yes – (Shattuck and Barnett 2001)		No
Vespidae					
Polistes spp.	Paper wasp	Yes – (Butani 1993)	Unknown – Genus is present in Australia (AICN 2004)	No[2] — No evidence of this genus being present on mango fruit. Adults feed on nectar and provision their larvae with insects, mainly caterpillars (CSIRO 1991).	No
INSECTA: ISOPTERA					
Kalotermitidae					
Neotermes bosei Snyder, 1933	Termite	Yes – (USDA 2001)	No record found	No[2] – Leaf, stem (USDA 2001)	No
Neotermes mangiferae Roonwal & Sen-Sarma, 1960	Termite	Yes – (Srivastava 1997)	No – (Watson and Abbey 1993)	No[2] – Root, stem (Butani 1993)	No
Neotermes megaoculatus Roonwal & Sen-Sarma, 1960	Termite	Yes – (Srivastava 1997)	No – (Watson and Abbey 1993)	No[2] – Root, stem (Butani 1993)	No
Rhinotermitidae					

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Coptotermes formosanus Shiraki, 1909	Formosan subterranean termite;	Yes – (Srivastava 1997)	No – (Watson and Abbey 1993)	No[2] – Branch, trunk (Peña and Mohyuddin 1997); root, wood (Srivastava 1997)	No
Coptotermes gestroi (Wasmann, 1896)	Subterranean termite	Yes – (Butani 1993)	No – (Watson and Abbey 1993)	No[2] – Root, stem (Butani 1993)	No
Coptotermes heimi (Wasmann, 1902)	Termite	Yes – (DPP 2001)	No – (Watson and Abbey 1993; Watson *et al.* 1998)	No[2] – Root, stem (Butani 1993)	No
Heterotermes indicola (Wasmann, 1902)	Termite	Yes – (DPP 2001)	No – (Watson and Abbey 1993; Watson *et al.* 1998)	No[2] – Root, stem (Butani 1993)	No
Stylotermes fletcheri (Holmgren, 1917)	Termite	Yes – (Srivastava 1997)	No – (Watson and Abbey 1993)	No[2] – Root, stem (Butani 1993)	No
Termitidae					
Microcerotermes edentatus (Wasmann)	Termite	Yes – (DPP 2001)	No – (Watson and Abbey 1993; Watson *et al.* 1998)	No[2] – Branch, trunk (Peña and Mohyuddin 1997); root, stem (Butani 1993)	No
Microtermes obesi Holmgren, 1913	Termite	Yes – (DPP 2001)	No – (Watson and Abbey 1993; Watson *et al.* 1998)	No[2] – Branch, trunk (Peña and Mohyuddin 1997); root, stem (Butani 1993)	No
Odontotermes assmuthi Holmgren, 1913	Termite	Yes – (Srivastava 1997)	No – (Watson and Abbey 1993)	No[2] – Root, stem (Butani 1993)	No
Odontotermes feae (Wasmann, 1896)	Termite	Yes – (Srivastava 1997)	No – (Watson and Abbey 1993)	No[2] – Root, stem (Butani 1993)	No
Odontotermes horni (Wasmann)	Termite	Yes – (Thakur 1981)	No – (Watson and Abbey 1993)	No[2] – Root, stem (USDA 2001)	No
Odontotermes obesus (Cambur, 1842)	Termite	Yes – (Thakur 1981; DPP 2000)	No – (Watson and Abbey 1993; Watson *et al.* 1998)	No[2] – Branch, root, stem, trunk (Srivastava 1997)	No
Odontotermes wallonensis (Wasmann, 1902)]	Termite	Yes – (Veeresh *et al.* 1989)	No – (Watson and Abbey 1993)	No[2] – Branch, root, stem (Srivastava 1997); trunk (Tandon and Srivastava 1982)	No
Trinervitermes biformis (Wasmann, 1902)	Snouted harvester termite	Yes – (Srivastava 1997)	No – (Watson and Abbey 1993)	No[2] – Root, stem (Butani 1993)	No
Trinervitermes rubidus (Hagen, 1859)	Termite	Yes – (Srivastava 1997)	No – (Watson and Abbey 1993)	No[2] – Root, stem (Butani 1993)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
INSECTA: LEPIDOPTERA					
Arctiidae					
Amsacta lactinea (Cramer, 1777)	Red tiger moth; black hairy caterpillar	Yes – (Butani 1993)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Pericallia ricini (Fabricius, 1775)	Leaf eating caterpillar	Yes – (Chockalingam and Krishnan 1984)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Chockalingam and Krishnan 1984)	No
Spilosoma obliqua (Walker, 1865)	Common hairy caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Cosmopterigidae					
Pyroderces simplex Walsingham, 1891	Flower eating caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Inflorescence (DPP 2001)	No
Gelechiidae					
Anarsia epotias Meyrick	Leaf eating caterpillar	Yes – (Bhumannavar 1990)	No – (Nielsen *et al.* 1996)	No[2] –Leaf (Srivastava, 1997)	No
Anarsia lineatella Zeller, 1839	Peach twig borer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf, stem (DPP 2001); shoot (Srivastava 1997)	No
Anarsia melanoplecta Meyrick 1914	Shoot borer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Inflorescence, leaf, stem (DPP 2001); shoot (Srivastava 1997)	No
Hypatima haligramma Meyrick, 1926	Shoot borer	Yes – (USDA 2001)	No record found	No[2] – Leaf (USDA 2001)	No
Hypatima spathota (Meyrick, 1913)	Shoot borer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Butani 1993; Patel *et al.* 1997)	No
Geometridae					
Biston suppressaria Guenée, 1858	Tea looper moth; looper caterpillar; tung oil tree looper	Yes – (Gupta and Singh 1988b)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Eucrostes sp.	Moth	Yes – (Verghese and Jayanthi 1999)	? – Genus is present in Australia (Nielsen *et al*. 1996)	No[2] – Inflorescence (Verghese and Jayanthi 1999)	No
Eupithecia sp.	Moth	Yes – (Singh *et al.* 1976)	No – (Nielsen *et al*. 1996)	No[2] – Leaf, shoot (Singh *et al*. 1976)	No
Hyposidra talaca (Walker, 1860)	Black inch worm	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No
Thalassodes dissita (Walker, 1861)	Leaf eating caterpillar	Yes – (Jadhav and Dalvi 1987)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Jadhav and Dalvi 1987)	No
Thalassodes quadraria Guenée, 1858	Leaf eating caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Thalassodes veraria Guenée, 1857	Leaf eating caterpillar	Yes – (Zaman and Maiti 1994)	Yes – (Nielsen *et al.* 1996)		No
Gracillariidae					
Acrocercops cathedraea Meyrick, 1908	Leafminer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf, stem (Butani 1993)	No
Acrocercops isonoma Meyrick, 1916	Leafminer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf, stem (Butani 1993)	No
Acrocercops pentalocha Meyrick, 1912	Leafminer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf, stem (Butani 1993)	No
Acrocercops syngramma Meyrick, 1914	Cashew leafminer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf, stem (Butani 1993)	No
Acrocercops zygonoma Meyrick, 1921	Leafminer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf, stem (DPP 2001); shoot (Srivastava 1997)	No
Heliodinidae					
Stathmopoda auriferella Walker, 1864	Moth	Yes – (USDA 2001)	No – (Nielsen *et al.* 1996)	No[2] – Fruit apex and stalk (Park *et al.* 1994) USDA (2001) states it is confined to the stem and thus not on pathway.	No
Lasiocampidae					
Gastropacha pardale (Walker, 1855)	Lappet moth	Yes – (Haseeb *et al.* 1998)	No – (Niesen *et al*. 1996)	No[2] – Leaf (Haseeb *et al.* 1998)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Limacodidae					
Chalcoscelides castaneipars (Moore, 1866)	Moth	Yes – (USDA 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (USDA 2001)	No
Cheromettia laleana Moore, 1859	Leaf eating caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Butani 1993)	No
Parasa lepida (Cramer, 1799)	Nettle caterpillar	Yes – (Srivastava 1997)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (CAB International 2007)	No
Phocoderma velutina (Kollar, 1844)	Leaf eating caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Butani 1993)	No
Lycaenidae					
Deudorix isocrates (Fabricius, 1793)	Pomegranate fruit borer	Yes – (Srivastava 1997)	No – (Nielsen *et al.* 1996)	Yes[3] – The pest attacks the fruit, but infested fruit rots and drops from the tree prematurely. The larval entry hole on the surface of infested fruit is visible due to the presence of grassy material around it (Srivastava 1997). Therefore, infested fruit is very unlikely to be packed for export. This species was previously considered in the 2004 Draft with an unrestricted risk rating of ‘very low’.	No
Rapala iarbus iarbus (Fabricius, 1787)	Indian red flash	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Butani 1993)	No
Rapala manea (Hewitson, 1863)	Slate flash	Yes – (Johnson *et al.* 1980)	No – (Nielsen *et al.* 1996)	No[2] – Flower (Johnson *et al.* 1980); leaf (Butani 1993)	No
Rathinda amor (Fabricius, 1775)	Monkey puzzle	Yes – (USDA 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (USDA 2001)	No
Lymantridae					
Euproctis flava (Bremen, 1861)	Oriental tussock moth	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Butani 1993)	No
Euproctis fraterna Moore, 1872	Coffee hairy caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Inflorescence (Verghese and Jayanthi 1999); leaf (Butani 1993)	No
Euproctis lunata Walker, 1855	Castor hairy caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Butani 1993)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Euproctis scintillans (Walker, 1856)	Tussock caterpillar	Yes – (Srivastava 1997)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Euproctis xanthosticha Hampson	Leaf eating caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Butani 1993)	No
Laelia sp.	Moth	Yes – (Bhole *et al.* 1987)	Unknown – Genus is present in Australia (Nielsen *et al.* 1996)	No[2] – Larvae feed on foliage of woody shrubs and trees, less frequently on herbaceous plants (Common 1990). Other Indian species of *Laelia* are recorded feeding usually on grasses and occasionally palms (Robinson *et al*. 2004).	No
Lymantria ampla (Walker, 1855)	Leaf eating caterpillar	Yes – (Srivastava 1997)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Lymantria beatrix Stoll, 1790	Tussock moth	Yes – (Singh and Kumar 1991)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Singh and Kumar 1991)	No
Lymantria marginata Walker, 1855	Mango defoliator	Yes – (Singh 1989)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Lymantria mathura Moore, 1865	Rosy (pink) gypsy moth	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Inflorescence, stem (DPP 2001); found on leaves of mango (Srivastava 1997; Robinson *et al.* 2004)	No
Olene mendosa Hübner, 1823	Tussock caterpillar	Yes – (Zaman and Maiti 1994)	Yes – (Nielsen *et al.* 1996)		No
Orgyia postica (Walker, 1885)	Cocoa tussock moth	Yes – (DPP 2001; Wakamura *et al.* 2005)	No – (Nielsen *et al.* 1996)	Yes – Fruit, leaf, panicle, shoot (Wakamura *et al.* 2005); stalk (Gupta and Singh 1986)	Yes
Perina nuda (Fabricius, 1787)	Clear-winged tussock moth	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Feeds on leaves of mango in India (Srivastava 1997)	No
Metarbelidae					
Indarbela dea (Swinhoe, 1890)	Bark borer; bark eating caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Bark, branch, stem (Neef 2005); twig (DPP 2000)	No
Indarbela quadrinotata (Walker, 1856)	Bark brown borer; bark borer	Yes – (Peña and Mohyuddin 1997; DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Bark, branch, trunk (Srivastava 1997); stem (Butani 1993)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Indarbela tetraonis (Moore, 1879)	Orange shoot borer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Bark (Srivastava 1997); stem (Butani 1993)	No
Indarbela theivora (Hampson, 1910)	Bark eating caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Bark (Srivastava 1997); stem (Butani 1993)	No
Noctuidae					
Achaea janata (Linnaeus, 1758)	Castor oil looper; croton caterpillar	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No
Autoba versicolor Walker, 1864	Flower webber	Yes – (DPP 2000)	No – (Nielsen *et al.* 1996)	No[2] – Inflorescence (DPP 2000)	No
Chlumetia alternans Moore, 1882	Shoot borer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Inflorescence, shoot (USDA 2001); leaf, stem (Butani 1993)	No
Chlumetia transversa (Walker, 1863)	Mango shoot borer	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No
Eublemma abrupta (Walker)	Flower feeding caterpillar	Yes – (USDA 2001)	Yes – (APPD 2007)		No
Eublemma angulifera Moore, 1882	Flower feeding caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Inflorescence (Butani 1993)	No
Eublemma brachygonia Hampson	Flower feeding caterpillar	Yes – (USDA 2001)	No records found	No[2] – Inflorescence (Butani 1993)	No
Eublemma silicula Swinhoe, 1897	Earhead caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Inflorescence (Butani 1993)	No
Eublemma versicolor Walker	Flower webber	Yes – (DPP 2000)	No – (Nielsen *et al.* 1996)	No[2] – Inflorescence (DPP 2000)	No
Eudocima fullonia (Clerck, 1764)	Fruit piercing moth	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No
Eudocima homaena (Hübner, 1816)	Fruit piercing moth	Yes – (Atwal 1976)	No – (Nielsen *et al.* 1996)	No[2] – External fruit feeding moths, active only at night. Because of their size, mobility and night-feeding, not likely to be on harvested fruit (USDA 2001)	No
Eudocima materna (Linnaeus, 1767)	Fruit piercing moth	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Helicoverpa armigera (Hübner, 1805)	Cotton bollworm; African cotton bollworm; corn earworm; fruit borer; gram pod borer; old world bollworm; tobacco budworm; tomato grub	Yes – (IIE 1993b)	Yes – (IIE 1993b)		No
Oraesia emarginata (Fabricius, 1794)	Fruit piercing moth	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No
Penicillaria jocosatrix Guenée, 1952	Large mango tip borer	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No
Selepa celtis Moore, 1858	Aonla hairy caterpillar	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No
Notodontidae					
Stauropus alternus Walker, 1855	Crab caterpillar; lobster caterpillar; lobster moth	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Nymphalidae					
Euthalia aconthea garuda (Moore, 1858)	Common baron	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997; Waterhouse 1998)	No
Euthalia nais (Forster, 1771)	Baronet	Yes – (Singh and Satyanarayana 2000)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Singh and Satyanarayana 2000)	No
Melanitis leda ismene (Cramer, 1775)	Rice butterfly	Yes – (CAB International, 2003)	Yes – (CAB International, 2003)	No[2] – Leaf (CAB International, 2003)	No
Pyralidae					

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Cadra cautella (Walker, 1863)	Almond moth	Yes – (Rajendran and Chayakumari 2003; Thangjam *et al.* 2003)	Yes – (Nielsen *et al.* 1996)		No
Citripestis eutraphera (Meyrick)	Fruit borer	Yes – (Bhumannavar 1991a; DPP 2001)	No – (Nielsen *et al*. 1996)	No – Fruit, but if affected, drops prematurely (Bhumannavar 1991a)	No
Conogethes punctiferalis (Guenée, 1854)	Castor seed caterpillar	Yes – (Srivastava 1997)	Yes – (AICN 2006)		No
Cryptoblabes gnidiella (Millière, 1867)	Honeydew moth	Yes – (Zhang 1994)	No – (Nielsen *et al.* 1996)	No[2, 3] – This species was previously considered to be present on pathway (DAFF 2004). Evidence used in the 2004 Draft to support pathway association considered this species as a biocontrol agent on whiteflies rather than as a pest of mango (Butani 1993; Mau and Kessing 1992; USDA 2006). No information found on this species attacking mango fruit (Butani 1993; Mau and Kessing 1992; USDA 2006). .	No
Ctenomeristis ebriola Meyrick, 1934	Mango caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	Yes – Fruit (Butani 1993; DPP 2001)	Yes
Deanolis sublimbalis Snellen, 1899	Red-banded mango caterpillar	Yes – (DPP 2001)	Yes – Under official control in QLD (QDPIF 2005)	Yes – Fruit (Zaheruddeen and Sujatha 1993; Srivastava 1997; Waterhouse 1998)	Yes
Hypsopygia mauritialis (Boisduval, 1833)	Moth	Yes – (USDA 2001)	Yes – (Nielsen *et al.* 1996)		No
Lamida carbonifera Meyrick, 1932	Mango leaf webber	Yes – (Srivastava 1997)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Lamida moncusalis Walker, 1859	Cashew leaf webber	Yes – (Srivastava 1997)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Lamida sordidalis Hampson, 1916	Leaf webber	Yes – (Srivastava 1997)	No – (Nielsen *et al.* 1996)	No[2] – Leaf, shoot (Srivastava 1997)	No
Maruca vitrata (Fabricius, 1787)	Bean pod borer	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Monopis leuconeurella (Ragonot, 1888)	Fruit borer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[3] – Fruit (DPP 2001). However, Ponnuswami (1971) and USDA (2006) note this species is very unlikely to follow the pathway because larval infestations generally cause fruit to drop before harvest, fruit injury is very noticeable and causes fruit to be unfit for sale.	No
Orthaga euadrusalis Walter, 1859	Tent caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No – Leaf, shoot (Tandon and Srivastava 1982)	No
Orthaga exvinacea Hampson, 1891	Mango leaf webber	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No
Orthaga mangiferae Mishra, 1932	Leaf webber	Yes – (Gupta and Rai 1982)	No – (Nielsen *et al.* 1996)	No – Leaf (Srivastava 1997)	No
Scirpophaga excerptalis Walker, 1863	Sugarcane top borer; sugarcane top moth borer; white top borer	Yes – (Lewvanich 1981)	Yes – (Lewvanich 1981)		No
Thylacoptila paurosema Meyrick, 1885	Fruit borer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[3] – Fruit (DPP 2001). However, Butani (1993) notes this species is very unlikely to follow the pathway because larval infestations generally cause fruit to drop before harvest, fruit injury is very noticeable and causes fruit to be unfit for sale.	No
Tirathaba mundella Walter, 1865	Oil palm bunch moth	Yes – (Bhumannavar and Jacob 1990)	No records found	No – Fruit (DPP 2001). However, Bhumannavar and Jacob (1990) note that this species is very unlikely to follow the pathway because larval infestations generally cause fruit to drop before harvest, fruit injury is very noticeable and causes fruit to be unfit for sale.	No
Saturnidae					
Attacus atlas (Linnaeus, 1758)	Atlas moth; giant Indian silkworm; snake head moth	Yes – (CAB International 2007)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (CAB International 2007)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Cricula trifenestrata (Helfer, 1837)	Mango hairy caterpillar	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Singh 1992)	No
Sphingidae					
Acherontia styx (Westwood, 1847)	Indian death's head hawkmoth	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Eggs are laid on leaves, and larvae feed on leaves and shoots (CAB International 2007)	No
Agrius convolvuli (Linnaeus, 1758)	Sweet potato moth	Yes – (DPP 2001)	Yes – (Common 1990; Nielsen *et al.* 1996)		No
Tineidae					
Hypophrictis plana Meyrick	Moth	Yes – (USDA 2001)	No – (Nielsen *et al.* 1996)	No[2] – Stem (USDA 2001)	No
Tortricidae					
Dudua aprobola (Meyrick, 1886)	Moth	Yes – (DPP 2001)	Yes – (Nielsen *et al.* 1996)		No
Enarmonia anticipans Meyrick, 1927	Moth	Yes – (USDA 2001)	No records found	No[2] – Inflorescence (USDA 2001)	No
Gatesclarkeana erotias (Meyrick, 1905)	Shoot borer	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf, stem (Butani 1993); shoot (Srivastava 1997)	No
Homona coffearia (Nietner, 1861)	Coffee tortrix	Yes – (USDA 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (CAB International 2007)	No
Homona permutata Meyrick, 1928	Leaf eating caterpillar	Yes – (Bhumannavar 1991b)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Srivastava 1997)	No
Strepsicrates rhothia (Meyrick, 1910)	Eucalyptus leafroller	Yes – (DPP 2001)	No – (Nielsen *et al.* 1996)	No[2] – Leaf (Butani 1993)	No
INSECTA: ORTHOPTERA					
Acrididae					
Aularches miliaris (Linnaeus, 1758)	Spotted grasshopper; spotted locust	Yes – (DPP 2001)	No – (Rentz 2006)	No[2] – Leaf (Butani 1993)	No
Gryllidae					
Gryllus viator Kirby	Grasshopper	Yes – (Butani 1993)	No records found	No[2] – Leaf (Butani 1993)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Platygryllus melanocephalus (Serville, 1839)	Field cricket	Yes – (DPP 2001)	No – (Rentz 2006)	No[2] – Leaf (Butani 1993)	No
Tarbinskiellus portentosus (Lichtenstein, 1796)	Rice field cricket; brown field cricket; large brown cricket	Yes – (Butani 1993)	No – (CAB International 2007)	No[2] – Leaf (USDA 2001)	No
INSECTA: THYSANOPTERA					
Aeolothripidae					
Aeolothrips collaris Priesner, 1919	Thrips	Yes – (DPP 2001)	No – (Mound 2005)	No[2] – Bud, inflorescence, leaf (Srivastava 1997)	No
Phlaeothripidae					
Haplothrips ganglbaueri Schmutz, 1913	Thrips	Yes – (DPP 2001)	No – (Mound 2005)	No[2] – Bud, inflorescence, leaf (Srivastava 1997)	No
Haplothrips tenuipennis Bagnall	Black tea thrips	Yes – (Srivastava 1997)	No – (Mound 1996)	No[2] – Bud, inflorescence, leaf (Srivastava 1997)	No
Neoheegeria mangiferae (Priesner)	Thrips	Yes – (Srivastava 1997)	No – (Mound 1996)	No[2] – Bud, inflorescence, leaf (Srivastava 1997)	No
Thripidae					
Anaphothrips sudanensis Trybom, 1911	Thrips	Yes – (Srivastava 1997)	Yes – (Mound 1996)		No
Caliothrips indicus (Bagnall, 1913)	Groundnut thrips	Yes – (DPP 2001)	No – (Mound 2005)	No[2] – Leaf (Butani 1993)	No
Caliothrips impurus Preisner, 1928	Thrips	Yes – (Patel *et al.* 1997)	No – (Mound, 1996)	No[2] – Leaf, root (Patel *et al*., 1997)	No
Frankliniella occidentalis (Pergande, 1895)	Western flower thrips	Yes – (Srivastava 1997)	Yes – (CAB International 2007)	No[2] – bud, inflorescence, leaf (Srivastava 1997)	No
Heliothrips haemorrhoidalis (Bouché, 1833)		Yes – (Mound and Walker 1987)	Yes – (Mound 1996)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Megalurothrips distalis (Karny, 1913)	Blossom thrips	Yes – (Ramasubbarao and Thammiraju 1994)	No – (Mound 1996)	No[2] – No evidence of this species being present on mango fruit. Inflorescence, leaf (USDA 2006; CAB International 2007)	No
Pantachaetothrips sp.	Thrips	Yes – (Patel *et al*. 1997)	No – (Mound 1996)	No[2] – Leaf (Patel *et al*. 1997)	No
Retithrips syriacus (Mayet, 1890)	Castor thrips; black vine thrips	Yes – (USDA 2001)	No – (Mound 1996)	No[2] – Leaf (Peña and Mohyuddin 1997)	No
Rhipiphorothrips cruentatus Hood, 1919		Yes – (More *et al.* 2003)	No – (Mound 2005)	Yes – Fruit and leaves (Lee and Wen 1982).	Yes
Scirtothrips dorsalis Hood, 1919	Strawberry thrips	Yes – (Srivastava 1997)	Yes – (Mound 1996)		No
Scirtothrips mangiferae Priesner, 1932	Mango thrips	Yes – (Srivastava 1997)	No – (Mound 1996)	No[2] – Bud, inflorescence, leaf (Srivastava 1997)	No
Selenothrips rubrocinctus (Giard, 1901)	Red banded thrips	Yes – (Srivastava 1997)	Yes – (Johnson and Parr 1999; Mound 2005)		No
Thrips hawaiiensis (Morgan, 1913)]	Banana flower thrips	Yes – (Tandon and Srivastava 1982)	Yes – (Mound 1996)		No
Thrips palmi Karny, 1925	Melon thrips	Yes – (Srivastava 1997)	Yes – (Mound 1996)		No
Thrips subnudula (Karny, 1926)	Thrips	Yes – (Srivastava 1997)	Yes – (Mound 2005)		No
Thrips tabaci Lindeman, 1888	Onion thrips	Yes – (CAB International 2007)	Yes – (Mound 1996)	No[2] – Inflorescence, leaf (CAB International 2007)	No
PATHOGENS					
Algae					
Cephaleuros falcata Kunze		Yes – (Vala *et al.* 1989)	No records found	No[2] – Infects leaves and stems (Vala *et al.* 1989)	No
Cephaleuros virescens Kunze		Yes – (Alfieri *et al.* 1994)	Yes – (Alfieri *et al.* 1994)		No
Bacteria					
Bacillus subtilis (Ehrenberg 1835) Cohn 1872	Soil rot	Yes – (DPP 2001)	Yes – (DAWA 2003)	No[2] – Root (US EPA 1999)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Pantoea agglomerans (Swing and Fife 1972) Gavini *et al.* 1989	Bacterial grapevine blight	Yes – (DPP 2001)	Yes – (CAB International 2007)	No[2] – Leaf (DPP 2001)	No
Pectobacterium carotovorum subsp. *caratovorum* (Jones 1901) Waldee 1945	Bacterial rot	Yes – (DPP 2001)	Yes – (Chandrashekar and Diriwaechter 1984)		No
Pseudomonas syringae pv. *syringae* van Hall 1902	Bacterial canker or blast (stone and pome fruits)	Yes – (DPP 2001)	Yes – (Wimalajeewa *et al.* 1991)		No
Rhizobium radiobacter (Beijerinck & van Delden 1902) Young *et al.* 2001	Crown gall	Yes – (Bradbury 1986)	Yes (Bradbury 1986)	No[2] – Root, stem (Bradbury 1986)	No
Xanthomonas campestris pv. *mangiferaeindicae* (Patel *et al.* 1948) Robbs *et al.* 1974	Bacterial black spot	Yes – (Rawal 1998)	Yes – (Bradbury 1986; Shivas 1989)		No
Diseases Of Unknown Etiology					
Mango crinkle disease		Yes – (Prakash *et al.* 1985)	No records found	No[2]	No
Fungi					
Actinodochium jenkinsii Uppal, Patel & Kamat	Black spot	Yes – (Uppal *et al.* 1953)	No records found	No[2] – Fruit (Uppal *et al.* 1953). Only known to infect wounded fruit (Uppal *et al.* 1953), and therefore very unlikely to be present on the export fruit pathway.	No
Alternaria alternata (Fr.: Fr.) Keissl.	Alternaria leaf spot	Yes – (Chattannavar *et al.* 1989)	Yes – (DAWA 2003; Ash and Lanoiselet 2001)		No
Alternaria tenuissima (Kunze ex Pers.) Wiltshire	Alternaria leaf spot	Yes – (DPP 2001)	Yes – (Ray *et al.* 2005)	No[2] – Leaf (DPP 2001)	No
Aplosporella beaumontiana S. Ahmad		Yes – (Om *et al.* 1985)	No records found	No[2] – Leaf, stem (Om *et al.* 1985)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Aspergillus fumigatus Fresen.		Yes – (Farr *et al.* 2007)	Yes – (APPD 2007)		No
Aspergillus nidulans (Eidam) Wint.		Yes – (Farr *et al.* 2007)	Yes – (APPD 2007)		No
Aspergillus niger Tiegh.	Aspergillus ear rot; black mould	Yes – (CAB International 2007)	Yes – (Pitkethley 1998; DAWA 2003)		No
Aspergillus stellifer Samson & Gams Teleomorph: *Emericella variecolor* Berk. & Broome]		Yes – (Samson and Pitt 1986)	Yes – (APPD 2007)		No
Aspergillus terreus Thom & Church		Yes – (Patel *et al.* 1985)	Yes – (Dewan and Sivasithamparam 1988; APPD 2008)		No
Asterolibertia mangiferae Hansf. & Thirum.		Yes –(Reddy 1975)	No – (APPD 2007)	No[2] – Leaf (Rangaswami *et al.* 1970)	No
Athelia rolfsii (Curzi) C.C.Tu & Kimbr. Anamorph: *Sclerotium rolfsii* Sacc.	Collar rot	Yes – (CAB International 2007)	Yes – (Conde and Diatloff 1991)		No
Aureobasidium pullulans (de Bary) G. Arnaud		Yes (Sarbhoy *et al.* 1975)	Yes – (APPD 2007)		No
Bipolaris australiensis (M.B. Ellis) Tsuda & Ueyama Teleomorph: *Cochliobolus australiensis* (Tsuda & Ueyama) Alcorn]		Yes	Yes – (Alcorn 1983)	No[2] – Leaf, seed (Sivanesan 1987)	No
Botryodiplodia theobromae Pat.		Yes – (Rawal 1998)	Yes – (CAB International 2007)		No
Botryosphaeria buteae Tilak & Kale		Yes – (Tilak and Kale 1969)	No records found	No[1] – Stem (Talde 1970; Sarbhoy *et al.* 1975). Species of *Botryosphaeria* that infect shoots and stems can usually infect fruits in which they may cause latent infections that are not expressed until the fruit has ripened (Slippers *et al.* 2005). Recent revisions of *Botryosphaeria* have not included *B. buteae* (Slippers *et al.* 2005; Crous *et al.* 2006).	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Botryosphaeria dothidea (Moug.) Ces. & De Not. Anamorph.: *Fusicoccum aesculi* Corda		Yes – (Prasad and Sinha 1979; Slippers *et al.* 2005)	Yes – (Slippers *et al.* 2005; Cunnington *et al.* 2007)		No
Botryosphaeria ribis Gross. & Duggar Anamorph: *Fusicoccum aesculi* Corda		Yes – (Balciunas and Center 1991)	Yes – (APPD 2007; Cunnington *et al.* 2007)		No
Capnodium mangiferum Cooke & Broome	Brown pod rot; sooty mould	Yes – (Sharma and Badiyala 1991)	Yes - (DAWA 2003)		No
Capnodium ramosum Cooke	Sooty mould of mango	Yes – (Sharma and Badiyala 1991)	Yes - (DAWA 2003)		No
Ceratocystis fimbriata Ellis & Halst.	Mango decline; Sudden tree death	Yes – (Somasekhara 1999)	Yes (Walker *et al.* 1988).		No
Ceratocystis paradoxa (Dade) C. Moreau Anamorph: *Thielaviopsis paradoxa* (De Seynes) Höhnel	Stem end rot disease	Yes (CMI 1987)	Yes – (APPD 2007) No records for NT or WA.	No[1] – A post harvest pathogen (CAB International 2007)	No
Cercospora mangiferae Koord.	Cercospora leaf spot	Yes – (DPP 2001)	No – (DAWA 2003)	No[2] – Leaves (Ploetz and Prakash 1997).	No
Cercospora mangiferae-indicae Munjal, Lall & Chona		Yes – (Rawal 1998)	No – (DAWA 2003)	No[2] – Leaves (Rawal 1998)	No
Chaetomium atrobrunneum L.M. Ames		Yes – (UKNCC 2008)	Yes[4] – (UKNCC 2008)		No
Ciliochorella mangiferae Syd.		Yes – (Rangaswami *et al.* 1970)	No – (APPD 2007)	No[2] – Leaves (Goos and Uecker 1992)	No
Cladosporium cladosporioides (Fresen.) G.A. de Vries	Black mould	Yes – (Singh and Kang 1989)	Yes – (Johnson *et al.* 1991; DAWA 2003)		No
Cladosporium herbarum (Pers.: Fr.) Link		Yes – (Rao 1966)	Yes (APPD 2007)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Coccomyces vilis Syd., P. Syd. & E.J. Butler		Yes – (Watson 1971; Sherwood 1980)	No – (APPD 2007)	No[2] – Leaves (Reddy 1975)	No
Colletotrichum acutatum J.H. Simmonds	Strawberry black spot	Yes – (CAB International 2007)	Yes – (Freeman *et al.* 2000; DAWA 2003)		No
Colletotrichum capsici (Syd.) E.J. Butler & Bisby	Leaf spot of peppers	Yes (Farr *et al.* 2007)	Yes – (Shivas 1989; DAWA 2004)		No
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc.	Anthracnose	Yes – (Sharma *et al.* 1994)	Yes – (Chakraborty *et al.* 1998)		No
Colletotrichum mangiferae Kelkar	Anthracnose	Yes – (Mathur 1979)	No records found	Yes – Leaf (USDA 2006).	No
Corticium koleroga (Cooke) Höhnel		Yes (USDA 2006)	No – (APPD 2007)	No[2] – Foliage (Sawant and Raut 1994)	No
Curvularia lunata (Wakker) Boedijn [Teliomorph *Cochliobolus lunatus* R.R. Nelson & Haasis]		Yes – (Reddy 1975; Sarbhoy *et al.* 1975)	Yes – (APPD 2007)	No[2] – Leaf, seedlings (Reddy 1975; Sarbhoy *et al.* 1975)	No
Curvularia tuberculata P.C. Jain [Teliomorph *Cochliobolus tuberculatus* Sivan.]	Blight disease	Yes – (Lele *et al*. 1981)	Yes – (APPD 2004) Not in WA (DAWA 2003)	No[2] – Leaf, shoot (Lele *et al*. 1981)	No
Cylindrocladiella camelliae (Venkataram. & C.S.V. Ram) Boesew.		Yes – (Crous and Wingfield 1993)	Yes[4] – (APPD 2007)		No
Cytospora mangiferae-indicae V.G. Rao & Narendra		Yes – (Rao and Narendra 1977)	No records found	No[2] – Leaves (Mathur 1979)	No
Cytosphaera mangiferae Died. [Teleomorph an undescribed species of *Cryptodiaporthe* (Johnson 1992)]		Yes – (Petrak and Sydow 1926)	Yes – (APPD 2007)		No
Discosia hiptages Tilak		Yes – (Subramanian and Chandra-Reddy 1974; Nag Raj 1993)	No records found	No[2] – Leaves (Sarbhoy *et al.* 1975; Cline 2008)	No
Earliella scabrosa (Pers.) Gilb. & Ryvarden.	White pocket rot	Yes – (DPP 2001)	Yes – (May *et al.* 2003)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Elsinoë mangiferae Bitan. & Jenkins	Mango scab	Yes – (Cook 2001)	Yes – (Conde *et al.* 2007) Not in WA (DAWA 2003)	Yes – Fruit, inflorescence, leaf, stem (Conde *et al.* 2007)	Yes
Exserohilum halodes (Drechs.) K.J. Leonard & Suggs Teleomorph: *Setosphaeria rostrata* K.J. Leonard]		Yes – (Sawant and Raut 1994)	Yes – (Shivas 1989; APPD 2007)		No
Fusarium decemcellulare Brick [Telemorph:*Albonectria rigidiuscula* (Berk. & Broome) Rossman & Samuels]	Cushion gall disease	Yes – (DPP 2001)	Yes – (APPD 2007)	.	No
Fusarium graminearum Schwabe [Teleomorph: *Gibberella zeae* (Schwein.) Petch]	Cobweb disease	Yes – (Saharan *et al.* 2004)	Yes – (Wildermuth and Purss 1971)		No
Fusarium incarnatum (Desm.) Sacc.		Yes – (DPP 2001)	Yes – (Sangalang *et al.* 1995; DAWA 2003; APPD 2007)		No
Fusarium mangiferae Britz, M.J. Wingf. & Marasas	Mango malformation	Yes – (Britz *et al.* 2002; Ploetz *et al.* 2002).	No – The disease mango malformation is under official control in the Northern Territory (DPIFM 2008). The pathogens causing mango malformation have recently been determined to be host specific (Britz *et al.* 2002)	Yes – Inflorescence, leaf, stem (Varma *et al.* 1974; Kumar *et al.* 1993). Conidia may contaminate the fruit surface. Infection of the fruit flesh and seed is not known (Freeman *et al.* 2004)	Yes
Fusarium moniliforme var. *subglutinans* Wollenw. & Reinking	Bunchy top; flower malformation	Yes – (Rawal 1998)	Yes – (DAWA 2003; CAB International 2007)	No[2] – Inflorescence, leaf, stem (Varma *et al*. 1974); shoot (Rawal 1998)	No
Fusarium oxysporum Schlechtendahl	Mango bunchy top	Yes – (Bhatnagar and Beniwal 1977)	Yes – (CAB International 2007)	Yes – Fruit (Gafar *et al*. 1979); inflorescence, panicle, panicle bearing shoot (Bhatnagar and Beniwal 1977)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Fusarium pallidoroseum (Cooke) Sacc.		Yes – (Singh and Devi 1990; Beegly 1999)	Yes (APPD 2007)		No
Fusarium solani (Mart.) Sacc. [Teleomorph: *Haematonectria haematococca* (Berk. & Broome) Samuels & Rossman]		Yes –(CAB International 2007)	Yes (APPD 2007)	No[2] – Root, stem –(CAB International 2007)	No
Fusarium subglutinans (Wollenw. & Reinking) P.E. Nelson, Toussoun & Marasas		Yes – (Rawal 1998)	Yes (APPD 2007)		No
Ganoderma applanatum (Pers.) Pat.	Ornamentals white butt rot	Yes – (DPP 2001)	No. Older records listed in APPD (2007) are misidentifications. *Ganoderma applanatum* is replaced by *G. australe* in the tropics (Steyaert 1975a, 1975b) and Australia (Smith and Sivasithamparam 2000, 2003). Distribution of *G. applanatum* and *G. australe* overlaps in NW India and Pakistan (Steyaert 1975a, 1975b)	No[2] – Stem (DPP 2001)	No
Geotrichum candidum Link	Fruit rot	Yes – (Badyal and Sumbali 1990)	Yes – (Wade and Morris 1982; DAWA 2003)		No
Gilbertella persicaria (E.D. Eddy) Hessel.	Gilbertella rot	Yes – (Prasad and Sinha 1979)	No records found	Yes[1] – Inflorescence, ripe fruit (Prasad and Sinha 1979). This fungus is a post harvest storage rot (Shane 2003).	No
Golovinomyces cichoracearum (DC.) V.P. Heluta var. *cichoracearum* [Anamorph: *Oidium asteris-punicei* Peck]	Powdery mildew	Yes – (Misra 2001)	Yes – (Shivas 1989; DAWA 2004; APPD 2007)		No
Guignardia mangiferae A.J. Roy [Anamorph *Phyllosticta anacardiacearum* van der Aa]	Phyllosticta rot	Yes – (Prasad and Sinha 1979)	Yes – (APPD 2007)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Hendersonia creberrima Syd, P. Syd. & E.J. Butler	Black spot	Yes – (Sutton and Dyko 1989; Cline 2006).	No records found	No[1] – Post harvest fruit rot (Sutton and Dyko 1989).	No
Hexagonia discopoda Pat. & Har.	Heart spongy rot	Yes – (DPP 2001)	No records found (May *et al.* 2003)	No[2] – (DPP 2001). This species is a wood rot (Dass and Teyegaga 1996) and there is currently no evidence to suggest it attacks mango fruit.	No
Hypoxylon hypomiltum Mont.		Yes – (Sarbhoy *et al.* 1975)	No records found	No[2] – Stem decay (Sarbhoy *et al.* 1975).	No
Lambertella aurantiaca V.P. Tewari & D.C. Pant		Yes – (Sarbhoy *et al.* 1975)	No records found	No[2] – Leaves (Sarbhoy *et al.* 1975)	No
Lasiodiplodia theobromae (Pat.) Griffin & Maubl.	Bark canker	Yes – (Rawal 1998)	Yes – (DAWA 2003; APPD 2007)		No
Laxitextum bicolor (Pers.: Fr.) Lenz		Yes – (Lenz 1956)	Yes – (May *et al.* 2003)		No
Leptoxyphium fumago (Woron.) R.C. Srivast.		Yes – (Om and Prakesh 1991, cited in USDA 2006; Beeghly 1999, cited in USDA 2006)	No – (APPD 2007)	No[2] – Leaf, shoot (Om and Prakesh 1991, cited in USDA 2006; Beeghly 1999, cited in USDA 2006)	No
Lophodermium mangiferae Koord.		Yes – (Cannon and Minter 1984; Vala *et al.* 1989)	No – (APPD 2007)	No[2] – Leaves (Vala *et al.* 1989)	No
Macrophoma mangiferae Hing. & Sharma	Leaf blight	Yes – (Verma and Singh 1996; Beeghly 1999)	No records found	No[1] –Causes post harvest fruit rot in mango fruit (Prasad and Sinha 1980). 'Fruit rot rarely occurs in nature, but commonly develops under storage' (Cline 2008). Symptoms easily detected in the field on mango leaves and stems, particularly on young seedlings and young grafted plants (Okigbo 2001; Okigbo and Osuinde 2003).	No
Macrophomina phaseolina (Tassi) Goid.		Yes – (Holliday 1980)	Yes – (APPD 2007)		No
Marasmius crinis-equi (F. Muell. ex Kalchbr.) Overeem		Yes – (Turner 1971)	Yes (Grgurinovic 1997)		No
Meliola mangiferae Earle	Black mildew	Yes – (Sharma and Badiyala 1991)	No records found	No[2] – Living leaves (Rodriguez and Minter 1998)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Microxiphium columnatum Bat., Cif. & Nascim.		Yes – (Om and Prakesh 1991, cited in USDA 2006; Beeghly 1999, cited in USDA 2006)	No – (APPD 2007)	No[2] –Shoot, stem (Prakash 1991)	No
Neofusicoccum mangiferae (Syd. & P. Syd.) Crous	Leaf spot, stem end rot	Yes (Sutton and Dyko 1989; Cline 2008)	Yes – In QLD and WA as *Nattrassia mangiferae* (APPD 2007)	No[1] – Fruit, leaf, stem (Reddy 1975; Farr *et al.* 2008)	No
Neoscytalidium dimidiatum (Penz.) Crous & Slippers		Yes (Farr *et al.* 1976)	Yes – As *Fusicoccum dimidiatum* and *Scytalidium dimidiatum* (APPD 2007)	No[1] – Fruit (NARA 2006). *Neoscytalidium dimidiatum* is a significant cause of post harvest fruit rot of mango in India (Slippers *et al.* 2005; Farr *et al.* 2007).	No
Nodulisporium indicum S.M. Reddy & Bilgrami		Yes – (Reddy and Bilgrami 1972)	No records found	No[2] – Leaf (Reddy and Bilgrami 1972).	No
Oidium mangiferae Berthet	Powdery mildew of mango	Yes – (Rawal 1998)	Yes – (DAWA 2003; APPD 2007)		No
Penicillium aurantiogriseum Dierckx	Blue mould rot; fruit rot	Yes – (Palejwala *et al.* 1989)	Yes – as *P. cyclopium* Westling.	No[1] – This species is a post harvest rot of mango fruit (Palejwala *et al.* 1989).	No
Penicillium dierckxii Biourge		Yes – (Reddy 1975)	No – (APPD 2007)	No[1] – This species is a post harvest rot of mango fruit (Reddy 1975)	No
Penicillium solitum var. *crustosum* (Thom) Bridge, D. Hawksw., Kozak., Onions, R.R.M. Paterson & Sackin	Fruit rot	Yes – (DPP 2001)	Yes – (APPD 2007)		No
Pestalotiopsis funerea (Desm.) Steyaert		Yes – (Farr *et al.* 2008)	Yes – (APPD 2007)		No
Pestalotiopsis glandicola (Castagne) Steyaert	Grey blight	Yes – (Ullasa and Rawal 1988)	Yes – (APPD 2007)		No
Pestalotiopsis mangiferae (Henn.) Steyaert	Grey leaf spot of mango	Yes – (Verma *et al.* 1991)	Yes – (Pitkethley 1998; DAWA 2003)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Pestalotiopsis theae (Saw.) Steyaert		Yes – (Kranz *et al.* 1977)	Yes – (APPD 2007)		No
Pestalotiopsis versicolor (Speg.) Steyaert	Grey blight	Yes – (DPP 2001)	Yes – (DAWA 2003; APPD 2007)		No
Pestalotiopsis virgatula Steyaert		Yes – (Reddy 1975; Farr *et al.* 2008)	No – (APPD 2007)	No[2] – Leaf (Reddy 1975)	No
Peziotrichum corticola (Massee) Subram.		Yes – (Petch 1927; Subramanian 1956)	Yes – (Kirk *et al.* 2001)		No
Phanerochaete salmonicolor (Berk. & Broome) Jülich	Pinks disease	Yes – (Rangaswami & Mahadevan 2004)	Yes – (May *et al.* 2003; APPD 2007)		No
Phellinus conchatus (Pers.: Fr.) Quél.	Heart spongy rot	Yes – (DPP 2001)	No records found Not in WA (DAWA 2003)	No[2] – This fungus causes wood rot where it is known to occur. There is currently no evidence to suggest it attacks mango fruit.	No
Phellinus gilvus (Schwein. Fri.) Pat.	White pocket rot	Yes – (DPP 2001)	Yes – (APPD 2007; DAWA 2004)		No
Phoma glomerata (Corda) Wollenb. & Hochapfel	Phoma blight	Yes – (Prakash and Singh 1977)	Yes – (APPD 2007)		No
Phoma sorghina (Sacc.) Boerema, Dorenb. & Kesteren [Teleomorph: *Leptosphaeria sacchari* Breda de Haan]		Yes – (Prakash and Raoof 1985)	Yes – (APPD 2008; DAWA 2008)		No
Phomopsis mangiferae S.Ahmad	Black fruit spot	Yes – (Laxminarayana and Reddy 1975; IMI 1995)	Yes – (Johnson *et al.* 1989; DAWA 2003)		No
Phyllosticta mortoni Fairm.		Yes – (Prajapati *et al.* 1989)	No records found	No[2] – Leaf (Prajapati *et al.* 1989)	No
Plenotrichella sp.		Yes – (Prakash and Raoof 1985)	No known records of this genus in Australia	No[2] – Leaf, twig (Prakash and Raoof 1985)	No
Rhizopus arrhizus A. Fisch.	Fruit rot	Yes – (Badyal and Sumbali 1990)	Yes – (APPD 2007)		No
Robillardia sessilis (Sacc.) Sacc.		Yes – (Prakash and Raoof 1985)	Yes[4] – (UKNCC 2008)		No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Rosellinia necatrix Berl. ex Prill.		Yes – (CAB International 2007)	Yes – (Bahl *et al.* 2005)		No
Schizophyllum commune Fr.	Sap rot	Yes – (DPP 2001)	Yes – (Shivas 1989; DAWA 2004)		No
Sclerotium delphinii Welch 1924	Sclerotium rot	Yes – (DPP 2001)	No records found No – (DAWA 2003)	No[2] – This fungus causes rot around the base of mango seedlings (Ploetz and Prakash 1997).	No
Stagonospora sp.		Yes – (Sinha and Singh 1991; Beeghly 1999)	Unknown. Species in this genus occur in Australia (APPD 2007).	No[2] – Leaf (Sinha and Singh 1991; Beeghly 1999)	No
Stigmina mangiferae Ellis	Spot blotch	Yes – (Kakoti *et al.* 1998)	Yes – Hyde 1992; Pitkethley 1998)		No
Synchytrium macrosporum Karling		Yes – (Sinha and Singh 1995)	No – (APPD 2007)	No[2] – Leaf, stem (Sinha and Singh 1995)	No
Thanatephorus cucumeris (A.B. Frank) Donk	Areolate leaf spot	Yes – (DPP 2001)	Yes – (Pitkethley 1998; DAWA 2003)		No
Trametes leonina (Klotsch.) Imazeki		Yes – (Bakshi *et al.* 1969)	Yes – (May *et al.* 2003)		No
Tripospermum myrti (Lind) S. Hughes	Sooty mould	Yes – (Prakash 1991)	No records found	Yes – Fruit (Prakash 1991); inflorescence, leaf, stem (DPP 2001). Sooty mould is the common name applied to species of fungi that grow on honeydew secretions on plant parts (Laemmlen 2003). Sucking insects are the primary cause of sooty mould growth. Sooty moulds are normally considered to be a cosmetic or aesthetic problem (Nameth *et al.* 2003). They do not infect plants but grow on surfaces where honeydew deposits accumulate. Fruits or vegetables covered with sooty moulds are edible and the mould can be removed with a solution of mild soap and warm water wash (Laemmlen 2003).	No
Straminopila					
Phytophthora arecae Coleman		Yes – (Rangaswami *et al.* 1970)	No records found	No[2] – Leaf, root, shoots (Ploetz and Mitchell 1989)	No

Pest	Common name	Present within India	Present within Australia	Considered present on the importation pathway	Consider further
Phytophthora nicotianae Breda de Haan		Yes – (Farr *et al.* 2008)	Yes – (APPD 2007)		No
Phytophthora palmivora (E.J. Butler) E.J. Butler		Yes – (Reddy 1975; Matheron and Matejka 1990)	Yes – (APPD 2007)	No[2] –Root, stem (Reddy 1975; Matheron and Matejka 1990)	No
Pythium splendens Braun		Yes – (CMI 1966; CAB International 2007; Farr *et al.* 2008)	Yes – (van der Plaats-Niterink 1981)		No

[1]As India's existing commercial production practices as described in Section 3.1.3 include a hot water fungicidal dip, post harvest rots are not considered to be on the pathway and therefore are not considered further.
[2] In its expert judgement, Biosecurity Australia considers that this pest is not associated with mango fruit.
[3] Although this pest was considered further in the Draft Report, further research indicates that it is not associated with export mango fruit.
[4]This was raised in the 2004 stakeholder comments as having area freedom. However, this species does not meet the definition of a pest under official control, therefore is not considered further in this assessment.

Appendix A.2: Potential for establishment, spread and consequences

Only valid names are used in this table. For lists of synonyms and outdated names refer to Appendix B.

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for economic consequences		Consider further in PRA?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
INSECTA: COLEOPTERA						
Curculionidae						
Sternochetus frigidus	Mango pulp weevil	Feasible	No record of presence in Australia found.	Significant	This pest is of major economic importance in India (DPP 2001). If introduced, this species has the potential to cause economic damage to Australian mango production.	Yes
Sternochetus mangiferae	Mango seed weevil	Feasible	*Sternochetus mangiferae* is present in Australia (Zimmermann 1994b). Not present in Western Australia.	Significant	This pest is of major economic importance in India (DPP 2001). Primary economic impact to Australia would be from quarantine restrictions imposed by important domestic and foreign export markets, rather than from direct yield losses from infested fruit.	Yes
INSECTA: DIPTERA						
Tephritidae						
Bactrocera caryeae	Fruit fly	Feasible	Susceptible hosts (e.g. mango) are present in Australia.	Significant	Primary economic impact to Australia would be from quarantine restrictions imposed by important domestic and foreign export markets, rather than from direct yield losses from infested fruit.	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for economic consequences		Consider further in PRA?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Bactrocera correcta	Guava fruit fly	Feasible	Moderate host range including guava, mango, cashew, mandarin, peach and melon (Allwood *et al.* 1999; Tsuruta *et al.* 1997).	Significant	In India, *B. correcta* is an important pest of guava, reported to inflict up to 80% damage on unprotected fruit (Mohamed Jalaluddin 1996).	Yes
Bactrocera cucurbitae	Melon fly	Feasible	Wide host range including many hosts that are present in Australia (Weems 1964).	Significant	*Bactrocera cucurbitae* is a very serious pest of cucurbit crops throughout its native range (tropical Asia) and in introduced areas such as the Hawaiian Islands (CAB International 2007). Damage levels can be anything up to 100% of unprotected crops (Armstrong 1983; *Mau et al. 2007*; Botha *et al.* 2004).	Yes
Bactrocera dorsalis	Oriental fruit fly	Feasible	Wide host range (Tsuruta *et al.* 1997; Allwood *et al.* 1999). Susceptible hosts are present in Australia.	Significant	Primary economic impact to Australia would result from quarantine restrictions imposed by important domestic and foreign export markets, rather than from direct yield losses from infested fruit.	Yes
Bactrocera invadens		Feasible	Wide host range and considered highly invasive as shown by its recent spread from the Indian subcontinent into Africa (Drew *et al.* 2005).	Significant	Has proven a serious pest species in Africa where it has become established (Drew *et al.* 2005).	Yes
Bactrocera tau	Fruit fly	Feasible	Infests fruit of susceptible hosts, which are grown in Australia (CAB International 2007).	Significant	Primary economic impact would result from quarantine restrictions imposed by important domestic and foreign export markets.	Yes
Bactrocera zonata	Peach fruit fly	Feasible	Polyphagous (White and Elson-Harris 1992). Susceptible hosts are present in Australia.	Significant	Important fruit fly pest and causes severe damage to peach, guava and mango (White and Elson-Harris 1992; Allwood *et al.* 1999).	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for economic consequences		Consider further in PRA?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
INSECTA: HEMIPTERA						
Diaspididae						
Abgrallaspis cyanophylli	Cyanophyllum scale	Feasible	Present in Australia, but is absent from Western Australia (AICN 2006). Its current distribution indicates conditions are suitable for this species to establish in WA.	Significant	Serious pest in Israel, USSR, USA (Florida) (Miller and Davidson 1990). This species has the potential to cause economic damage if introduced. Hosts present in Australia include mango, banana, avocado and Australian red cedar (Williams and Watson 1988).	Yes
Parlatoria crypta	Mango white scale	Feasible	This scale is a pest on plants from 23 families including many of which are grown commercially in Australia (Ben-Dov *et al.* 2006)	Significant	Listed as an insect pest (Miller and Davidson 1990; Ben-Dov *et al.* 2006). This species has the potential to cause economic damage if introduced. Hosts present in Australia include mango, *Malus* spp. and *Citrus* spp. (Ben-Dov *et al.* 2006).	Yes
Pseudococcidae						
Ferrisia malvastra	Malvastram mealybug	Feasible	This species is present in Australia (Queensland), but is absent from Western Australia (Ben-Dov *et al.* 2006). *Ferrisia malvastra* is polyphagous (Ben-Dov 2005) and a number of host plants are present in Western Australia. Always reproduces parthenogenetically (Ben-Dov 2005) and so could establish a population from a single specimen.	Significant	The economic importance of *F. malvastra* has not been established. This species is closely related to *F. virgata*, and confusion over species identification means that older references to damage on mango fruit caused by *F. virgata* may be referring to *F. malvastra.*	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for economic consequences		Consider further in PRA?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Ferrisia virgata	Striped mealybug	Feasible	This species is present in Australia (Ben-Dov *et al.* 2006) but is absent from Western Australia. Conditions are suitable for this species to establish in Western Australia. Polyphagous attacking plant species of 160 genera in 70 families (Ben Dov *et al.* 2006); susceptible hosts are freely available in the protected area.	Significant	A known vector of cocoa swollen shoot virus (CSSV) in West Africa and cocoa Trinidad virus (CTV, Diego Martin valley isolate) in Trinidad (Thorold 1975). This species is a pest of coffee, cotton, cashew and kenaf, and is a major pest of guava (Gullen *et al.* 2003; MacLeod 2006).	Yes
Margarodidae						
Perissopneumon ferox	Mealybug	Feasible	Susceptible hosts (e.g. mango, citrus, neem) are present in Australia (Ben-Dov *et al.* 2006).	Not Significant	This species was first recorded on mango in India in 1985 (Srivastava and Verghese 1985). Since then, only limited evidence has been published of this species attacking any host (including mango), therefore this species has not been considered further.	No
Pseudococcidae						
Planococcus lilacinus	Coffee mealybug	Feasible	Extremely wide host range (MacLeod 2006). Susceptible hosts are present in Australia.	Significant	*Planococcus lilacinus* is a pest of cocoa throughout the Orient and South Pacific (IIE 1995b). It also damages a wide variety of economically important crops such as coffee, tamarinds, custard apples, coconuts, citrus, grapes, guavas and mangoes (MacLeod 2006).	Yes
Rastrococcus iceryoides	Downey snowline mealybug	Feasible	A polyphagous species with hosts belonging to diverse botanical families (Ben-Dov 1994).	Significant	Major economic importance in India (DPP 2001). Causes damage to mangoes and citrus in India (CAB International 2007).	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for economic consequences		Consider further in PRA?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Rastrococcus invadens	Mealybug	Feasible	Wide host range (Ben-Dov *et al.* 2006).	Significant	Minor economic importance in India (Moore 2004). In fact, the species had not been recognised and was mistaken for *R. spinosus*, before it was accidentally introduced into Africa (Moore 2004). However, wherever this mealybug appeared in Africa it became a pest of prime importance on mango, sometimes on citrus, and on many other horticultural crops and shade trees (Agounké *et al.* 1988; Ivbijaro *et al.* 1992).	Yes
Rastrococcus spinosus	Philippine mango mealybug	Feasible	Susceptible hosts are present in Australia.	Significant	Major economic importance in India (DPP 2001).	Yes
INSECTA: LEPIDOPTERA						
Lymantriidae						
Orgyia postica	Cocoa tussock moth	Feasible	A species of forests and forest-steppe which has adapted well to orchards and forest plantations (Holloway 2007). Susceptible hosts are present in Australia.	Significant	In Taiwan, *O. postica* is a major pest of cultivated grapevines (Chang 1988). Larvae cause serious damage to young leaves of cacao in the Philippines, both in nurseries and plantations (Sanchez and Laigo 1968). When very numerous they can cause total defoliation, killing or stunting the tree (Sanchez and Laigo 1968).	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for economic consequences		Consider further in PRA?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Pyralidae						
Ctenomeristis ebriola Meyrick, 1934	Mango caterpillar	Feasible	Other species from this genus are present in Australia (Nielson *et al.* 1996). Conditions may be suitable for this species to establish. This species is thought to be monophagous and this may affect its ability to establish and spread (Butani 1993)	Not significant	This species was first recorded on mango fruit in India in 1955 (Butani 1993). No new independent evidence of this species attacking mango fruit anywhere in the world has been published since this date, therefore this species has not been considered further.	No
Deanolis sublimbalis	Red-banded mango caterpillar	Feasible	*Deanolis sublimbalis* is present in Australia (Queensland), but is under official control (QDPIF 2005).	Significant	A major pest in Orissa, India (Butani 1979). This species is known to have caused considerable damage in Andhra Pradesh, India in recent years (Zaheruddeen and Sujatha 1993). In tropical parts of Asia, it causes commercial losses in the order of 10-15% in mango (QDPIF 2005).	Yes
INSECTA: THYSANOPTERA						
Thripidae						
Rhipiphorothrips cruentatus Hood, 1919	Mango thrips	Feasible	Host range includes mango, guava, grapevine, pomegranate, cashew and sugar apple (CAB International 2007).	Significant	*Rhipiphorothrips cruentatus* is one of the most important pests of grapevine in India (Rahman and Bhardwaj 1937). In Taiwan, wax apple has been severely attacked (Chiu 1984), and other crops such as mango and guava have also been damaged (Chang 1995).	Yes
PATHOGENS						

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for economic consequences		Consider further in PRA?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Fungi						
Elsinoë mangiferae	Mango scab	Feasible	Establishment and spread is limited as mango is the only reported host. Dispersal of conidia is via rain and wind and germination is reliant on free water (Bitancourt & Jenkins 1943, 1946; CAB International 2007). Mature fruit is resilient to attack.	Significant	There are no reports of *E. mangiferae* infecting plants other than mango. However, losses from the disease can be relatively high if uncontrolled. Established in Australia (Northern Territory and Queensland) (CAB International 2007), but Western Australia has area freedom.	Yes
Fusarium mangiferae	Mango malformation	Feasible	Infection of the flesh and seed is not known, but conidia may contaminate the fruit surface (Freeman *et al.* 2004).	Significant	Considered an important disease of mango worldwide (Kumar *et al.* 1993). Destructive and difficult to control (Kumar *et al.* 1993).	Yes

Appendix B: Additional quarantine pest data

Quarantine pest	*Sternochetus frigidus* (Fabricus, 1787)
Synonyms	*Curculio frigidus* Fabricius, 1787; *Cryptorrhynchus gravis* Fabricius 1787; *Sternochetus gravis* (Fabricius, 1787); *Cryptorhynchus frigidus* (Fabricius 1787); *Acryptorrhynchus frigidus* (Fabricius, 1787).
Common name(s)	mango pulp weevil
Main hosts	*Mangifera indica* (mango), *Mangifera sylvatica* (Nepal mango) (Srivastava 1997). *Mangifera foetida* (bachang mango) (CAB International 2007).
Distribution	Bangladesh, Brunei Darussalam, India, Indonesia, Myanmar, Pakistan, Papua New Guinea, Philippines, Sinhapore, Thailand (CAB International 2007).
Quarantine pest	*Sternochetus mangiferae* (Fabricius, 1775)
Synonyms	*Cryptorhynchus mangiferae* Fabricius, 1775*; Acryptorhynchus mangiferae* (Fabricius 1775)*; Curculio mangiferae* (Fabricius 1775)*; Sternochetus ineffectus* (Walker 1859)*;*
Common name(s)	mango seed weevil
Main hosts	*Mangifera indica* (mango). Complete insect development is only achieved in mangoes. In the laboratory, oviposition has occurred on potatoes, peaches, lychees, plums and apples, but resulting larvae failed to reach maturity (EPPO 2007).
Distribution	Australia (Not in WA), Bangladesh, Barbados, Bhutan, Central African Republic, China (Hong Kong), Dominica, Fiji, French Guiana, French Polynesia (Society Islands), Gabon, Ghana, Guadeloupe, Guam, Guinea, India, Indonesia, Kenya, Liberia, Madagascar, Malawi, Malaysia (Peninsular, Sabah), Martinique, Mauritius, Mozambique, Myanmar, Nepal, New Caledonia, Nigeria, Réunion, Northern Mariana Islands, Pakistan, Seychelles, South Africa, Sri Lanka, St Lucia, Tanzania, Thailand, Tonga, Trinidad and Tobago, Uganda, United Arab Emirates, United States, United States Virgin Islands, Viet Nam, Wallis and Futuna Islands, Zambia (EPPO 2007).
Quarantine pest	*Bactrocera caryeae* (Kapoor, 1971)
Synonyms	*Dacus caryeae* Kapoor 1971, *Dacus poonensis* Kapoor 1971.
Common name(s)	Indian fruit fly
Main hosts	Hosts include: *Mangifera indica* (mango) (Peña and Mohyuddin 1997). White and Elson-Harris (1992) also list *Citrus* sp. (citrus) and *Psidium guajava* (common guava) as confirmed hosts, as well as *Coffea canephora* (robusta coffee), *Citrus reticulata* (tangerine) and *Ficus* sp.
Distribution	Southern India (White and Elson-Harris 1992)-Karnataka, Tamil Nadu (Clarke *et al.* 2005) and Maharashtra (Carroll *et al.* 2002). Sri Lanka (Clarke *et al.* 2005).
Quarantine pest	*Bactrocera correcta* (Bezzi 1916)
Synonyms	*Chaetodacus correctus* Bezzi 1916; *Dacus bangaloriensis* Agarwal & Kapoor 1983; *Dacus dutti* Kapoor 1971; *Strumeta paratuberculatus* Philip 1950; *Dacus correctus* (Bezzi, 1916).
Common name(s)	Guava fruit fly

Main hosts	Hosts include: *Mangifera indica* (mango), *Manilkara zapota* (sapodilla), *Psidium guajava* (guava), *Prunus persica* (peach), *Syzygium jambos* (rose-apple), *Terminalia catappa* (Indian almond), *Ziziphus jujuba* (jujube). Other recorded hosts include *Aegle marmelos* (Indian bael), *Carissa carandas* (karanda), *Citrus* sp., *Coffea canephora* (robusta coffee), *Eugenia uniflora* (Surinam cherry), *Ricinus communis* (castor-oil plant) and *Santalum album* (sandalwood) (White and Elson-Harris 1992).
Distribution	Nepal, Pakistan, Sri Lanka, Thailand, United States (individuals trapped in California, but population does not appear to have become established) (White and Elson-Harris 1992). In India, this pest often occurs with serious pest species such as *B. dorsalis* and *B. zonata* (Kapoor 1989).
Quarantine pest	*Bactrocera cucurbitae* (Coquillett, 1899)
Synonyms	*Dacus cucurbitae* Coquillett, 1899; *Chaetodacus cucurbitae* (Coquillett, 1899); *Dacus aureus* Tseng & Chu 1982; *Dacus yuiliensis* Tseng & Chu, 1992; *Strumeta cucurbitae* (Coquillett, 1899); *Zeugodacus cucurbitae* (Coquillett, 1899).
Common name(s)	Melon fly
Main hosts	*Bactrocera cucurbitae* is a very serious pest of cucurbit crops. According to Weems (1964) it has been recorded from over 125 plants, including members of families other than Cucurbitaceae. However, many of those records were based on casual observation of adults resting on plants or caught in traps set in non-host trees. Hosts include: *Carica papaya* (papaya, pawpaw) (Tsuruta *et al.* 1997); *Citrullus lanatus* (wild melon), *Cucumis melo* (melon) (Allwood *et al.* 1999); *Cucurbita maxima* (giantpumpkin) (Tsuruta *et al.* 1997); *Cucurbita pepo* (pumpkin, squash), *Lycopersicon esculentum* (tomato) (Allwood *et al.* 1999); *Mangifera indica* (mango) (CAB International 2007); *Manilkara zapota* (sapodilla), *Phaseolus vulgaris* (bean), *Psidium guajava* (guava); *Trichosanthes cucumerina* (snake gourd) (Tsuruta *et al.* 1997); *Vigna unguiculata* (cowpea) (Allwood *et al.* 1999).
Distribution	*Bactrocera cucurbitae* is widely distributed in Asia, but also occurs in Africa, North America and Oceania regions (CAB International 2007). In Asia, *B. cucurbitae* is recorded from Afghanistan (IIE 1995a); Bangladesh (CAB International 2007); Brunei Darussalam (Waterhouse 1993); Cambodia (IIE 1995a); China (CAB International 2007); India (Andaman and Nicobar Islands, Andhra Pradesh, Assam, Bihar, Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal) (CAB International 2007; IIE 1995a); Indonesia, Iran, Laos, Malaysia, Myanmar, Nepal, Oman, Pakistan, Philippines, Saudi Arabia (CAB International 2007); Sinhapore (IIE 1995a); Sri Lanka, Thailand, United Arab Emirates and Vietnam (CAB International 2007).
Quarantine pest	*Bactrocera dorsalis* (Hendel, 1912)
Synonyms	*Dacus dorsalis* Hendel, 1912; *Bactrocera conformis* Doleschall, 1858 (preocc.); *Bactrocera ferrugineus* (Fabricius, 1805); *Chaetodacus dorsalis* (Hendel, 1912); *Chaetodacus ferrugineus* (Fabricius, 1805); *Chaetodacus ferrugineus dorsalis* (Hendel, 1912); *Chaetodacus ferrugineus okinawanus* Shiraki, 1933; *Dacus ferrugineus* Fabricius, 1805; *Dacus ferrugineus* var. *dorsalis* Fabricius, 1805; *Dacus ferrugineus okinawanus* (Shiraki, 1933); Musca ferruginea Fabricius, 1794 (preocc.); Strumeta dorsalis (Hendel, 1912); Strumeta ferrugineus (Fabricius, 1805).
Common name(s)	Oriental fruit fly

Main hosts	*Bactrocera cucurbitae* is a very serious pest of cucurbit crops. According to Weems (1964) it has been recorded from over 125 plants, including members of families other than Cucurbitaceae. However, many of those records were based on casual observation of adults resting on plants or caught in traps set in non-host trees. Hosts include: *Carica papaya* (papaya, pawpaw) (Tsuruta *et al.*, 1997); *Citrullus lanatus* (wild melon), *Cucumis melo* (melon) (Allwood *et al.*, 1999); *Cucurbita maxima* (giant pumpkin) (Tsuruta *et al.*, 1997); *Cucurbita pepo* (pumpkin, squash), *Lycopersicon esculentum* (tomato) (Allwood *et al.*, 1999); *Mangifera indica* (mango) (CAB International 2007); *Manilkara zapota* (sapodilla), *Phaseolus vulgaris* (bean), *Psidium guajava* (guava); *Trichosanthes cucumerina* (snake gourd) (Tsuruta *et al.*, 1997); *Vigna unguiculata* (cowpea) (Allwood *et al.*, 1999).
Distribution	True *B. dorsalis* is restricted to mainland Asia (except the peninsula of southern Thailand and West Malaysia), as well as Taiwan and its adventive population in Hawaii (Drew and Hancock 1994). CAB International (2007) also includes California and Florida, USA, in the distribution because the fly is repeatedly trapped there in small numbers. This species is a serious pest of a wide range of fruit crops in Taiwan, southern Japan, China and in the northern areas of the Indian subcontinent (CAB International 2007). In Asia, *B. dorsalis* is recorded from Bangladesh (IIE, 1994b); Bhutan, Cambodia, China (Drew and Hancock, 1994); Guam (Waterhouse, 1993); Laos, Myanmar (Drew and Hancock, 1994); Nauru (Waterhouse, 1993); Nepal, Pakistan, Sri Lanka, Thailand, United States (Hawaii) and Vietnam (Drew and Hancock, 1994).
Quarantine pest	*Bactrocera invadens* Drew, Tsuruta and White, 2005
Synonyms	None
Common name(s)	None
Main hosts	Hosts include: *Mangifera indica* (mango), *Psidium guajava* (guava), *Carica papaya* (papaya), *Citrus* sp. (citrus). It is also known on a number of native African species (Drew *et al.* 2005). Sithananttham *et al.* (2006) also recorded it on tomato (*Lycopersicon esculentum*) and *Strychnos* spp
Distribution	India (Sithanantham *et al.* 2006). Benin, Cameroon, Ghana, Kenya, Nigeria, Senegal, Sri Lanka, Sudan, Tanzania, Togo, Uganda (Drew *et al.* 2005). Also Comosos, Côte d'Ivoire, Ethiopia, Democratic Republic of Congo, Bhutan (Sithanantham *et al.* 2006).
Quarantine pest	*Bactrocera tau* (Walker, 1909)
Synonyms	*Dacus tau* Walker, 1849; *Bactrocera (Zeugodacus) tau* (Walker, 1849); *Dacus hageni* (de Meijere, 1911); *Chaetodacus tau* (Walker, 1849); *Dacus caudatus* var. *nubilus* (Hendel, 1912); *Dacus nubilus* (Bezzi, 1912); *Dasyneura tau* (Walker, 1849)..
Common name(s)	Fruit fly
Main hosts	*Bactrocera tau* appears to show a preference for attacking the fruits of Cucurbitaceae, but it has also been reared from the fruits of several other plant families (CAB International 2007). Due to the recent separation of previously confused species, the host data given below were taken from a recently published host catalogue that was largely based on a 1990s survey carried out in Thailand and Malaysia (Allwood *et al.* 1999). Hosts include: *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Cucurbita maxima* (giant pumpkin), *Luffa acutangula* (angled luffa), *Momordica charantia* (balsam apple) (CAB International 2007); *Mangifera indica* (mango) (Peña and Mohyuddin 1997).

Distribution	Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China (Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hubei, Hong Kong, Sichuan, Taiwan, Yunnan, Zhejiang), India (Uttar Pradesh), Indonesia (Sumatra), Laos, Malaysia (Peninsular Malaysia, Sabah, Sarawak), Myanmar, Sinhapore, Thailand, Vietnam (CAB International 2007).
Quarantine pest	*Bactrocera zonata* (Saunders, 1842)
Synonyms	*Dasyneura zonatus* Saunders, 1841; *Dacus ferrugineus* var. *mangiferae* Cotes, 1893; *Rivellia persicae* Bigot, 1890; *Chaetodacus zonatus* (Saunders, 1841); *Dacus zonatus* (Saunders, 1842); *Dacus mangiferae* Cotes, 1893; *Dacus persicae* (Bigot, 1890); *Dacus zonatus* (Saunders, 1842); *Strumeta zonata* (Saunders, 1842); *Dasyneura zonata* Saunders, 1842; *Dacus persicus* (Bigot, 1890); *Strumeta zonatus* (Saunders, 1842).
Common name(s)	Peach fruit fly; guava fruit fly
Main hosts	*Bactrocera zonata* has been recorded on 32 host plants, including peach, guava, mango, fig, dates, okra and tomato (Alzubaidy 2000). It has also been recorded from wild host plants of the families Euphorbiaceae, Lecythidaceae and Rhamnaceae (Duyck *et al.* 2004). Hosts include: *Mangifera indica* (mango), *Prunus persica* (peach) and *Psidium guajava* (guava). Secondary hosts include: *Aegle marmelos* (bael tree), *Annona squamosa* (sugar apple), *Careya arborea* (slow match tree), *Carica papaya* (papaya, pawpaw), *Citrus* sp., *Cydonia oblonga* (quince), *Ficus carica* (fig), *Grewia asiatica* (phalsa), *Luffa* sp. (loofah), *Malus domestica* (apple), *Malus pumila* (paradise apple), *Momordica charantia* (bitter gourd), *Phoenix dactylifera* (date-palm), *Punica granatum* (pomegranate) and *Terminalia catappa* (Indian almond) (White and Elson-Harris 1992).
Distribution	Originating in tropical Asia, *B. zonata* has spread to other regions of the world including Africa and the Arab world. It currently occurs in Bangladesh, Egypt, India, Laos, Mauritius, Moluccus Islands, Myanmas, Pakistan, Reunion Island, Sri Lanka, Thailand and Vietnam (Alzubaidy 2000).
Quarantine pest	*Abgrallaspis cyanophylli* (Signoret, 1869)
Synonyms	*Aspidiotus cyanophylli* Signoret, 1869; *Fucaspis cyanophylli* Signoret; *Hemiberlesia cyanophylli* Signoret.
Common name(s)	Cyanophyllum scale
Main hosts	*Acalypha hispida* (chenille plant), *Annona squamosa* (sugar apple), *Annona* sp. (custard apple), *Artocarpus altilis* (breadfruit), *Bauhinia* sp., *Barringtonia* sp., *Camellia sinensis* (tea), *Capsicum ovatum*, *Ceiba pentandra* (kapok tree), *Cinnamomum verum* (cinnamon), *Clerodendrum* sp., *Coccoloba uvifera* (Jamaican kino, sea-grape), *Cocos nucifera* (coconut), *Coffea arabica* (arabica coffee), *Coffea* sp. (coffee), *Coleus* sp., *Cordyline fruticosa* (palm lily), *Dioscorea alata* (greater yam), *Dioscorea* spp. (yam), *Elettaria cardamomum* (cardamom), *Eriobotrya japonica* (loquat), *Eugenia* sp., *Ficus* sp. (fig), *Guettarda speciosa* (beach gardenia), *Hevea brasiliensis* (rubber tree), *Hibiscus syriacus* (rose-of-Sharon), *Jatropha curcas* (Barbados-nut), *Macadamia tetraphylla* (rough-shell Queensland nut), *Mangifera indica* (mango), *Manihot esculenta* (cassava), *Musa* × *paradisiaca* (banana), *Musa* sp. (banana), *Persea americana* (avocado), *Piper methysticum* (kava kava), *Plumeria rubra f. acutifolia* (Mexican frangipani), *Psidium guajava* (guava), *Swietenia macrophylla* (Honduras mahogany), *Theobroma cacao* (cocoa), *Toona ciliata* (Australian red cedar) (Williams and Watson 1988); *Nerium* sp. (oleander) (CAB International 2007).

Distribution	Cook Islands, Fiji, French Polynesia (Williams and Watson 1988); Georgia, India (CAB International 2007); Kiribati, New Caledonia, Papua New Guinea, Tonga, Tuvalu, Vanuatu, Western Samoa (Williams and Watson 1988). This species has also been recorded in Australia (New South Wales, Queensland, Tasmania), but not in Western Australia (AICN 2004).
Quarantine pest	*Parlatoria crypta* (McKenzie, 1943)
Synonyms	*Palatoria morrisoni* McKenzie, 1943; *Parlatoria* sp. Ghauri, 1962.
Common name(s)	Mango white scale
Main hosts	*Parlatoria crypta* is a highly polyphagous species that has been recorded on a range of hosts including *Asparagus*, *Azadirachta*, *Bauhinia*, *Carissa*, *Cassia*, *Citrus*, *Clerodendrum*, *Cocos*, *Cordia*, *Cordylia*, *Diospyros*, *Ethretia*, *Eriobotrya*, *Euronymus*, *Ficus*, *Grewia*, *Hibiscus*, *Jasminum*, *Laurus*, *Mallotus*, *Malus*, *Mangifera*, *Melia*, *Morus*, *Musa*, *Nerium*, *Olea*, *Phoenix*, *Podocarpus*, *Rosa*, and *Ziziphus* (Watson 2007).
Distribution	Afghanistan, Eritrea, India (Andhra Pradesh, Bihar, Delhi, Karnataka, Punjab and Uttar Pradesh) (Ben-Dov *et al.* 2006; Watson 2007), Iran, Iraq, Niger, Nigeria, Oman, Pakistan, Saudi Arabia, Sudan, West Malaysia and Yemen (Watson 2007).
Quarantine pest	*Ferrisia malvastra* (McDaniel, 1962)
Synonyms	*Heliococcus malvastrus* McDaniel, 1962; *Ferrisia virgata* Ben-Dov, 1980; *Ferrisia consobrina* Williams & Watson, 1988; *Ferrisia malvastra*; Williams, 1996.
Common name(s)	Malvastrum mealybug
Main hosts	This species has been recorded on at least 37 host species across 26 families, including Chenopodiaceae, Compositae, Cruciferae, Euphorbiaceae, Leguminosae, Palmae, Proteaceae, Rutaceae and Solanaceae (Ben-Dov *et al.* 2006).
Distribution	*Ferrisia malvastra* has been recorded from Argentina, Australia, Bahamas, Bermuda, Cook Islands, Cuba, India (Karnataka, Maharashtra) , Israel, Jamaica, Kiribati, Mexico, New Caledonia, Papua New Guinea, Peru, South Africa, Swaziland, Tonga, Trinidad, Tuvulu, and Vanuatu (Ben-Dov 2005). Some early geographical records of *F. virgata* may be referring to *F. malvastra* (Ben-Dov 1994).
Quarantine pest	*Ferrisia virgata* (Cockerell, 1893j)
Synonyms	*Dactylopius segregatus* Cockerell, 1893; *Dactylopius virgatus* Cockerell, 1893; *Dactylopius virgatus farinosus* Cockerell, 1893; *Dactylopius virgatus humilis* Cockerell, 1893; *Dactylopius ceriferus* Newstead, 1894; *Dactylopius talini* Green, 1896; *Dactylopius dasylirii* Cockerell, 1896; *Dactylopius setosus* Hempel, 1900; *Pseudococcus virgatus* Kirkaldy, 1902; *Dactylopius magnolicida* King, 1902; *Pseudococcus magnolicida* (Cockerell, 1902p); *Pseudococcus virgatus farinosus* (Cockerell, 1902p); *Pseudococcus dasylirii* (Fernald, 1903b); *Pseudococcus segregatus* (Fernald, 1903b); *Pseudococcus virgatus humilis* (Fernald, 1903b); *Dactylopius virgatus madagascariensis* Newstead, 1908; *Pseudococcus marchali* Vayssière, 1912; *Pseudococcus virgatus madagascariensis* (Lindinger, 1913); *Pseudococcus bicaudatus* Keuchenius, 1915; *Ferrisiana virgata* (Takahashi, 1929a); *Heliococcus malvastrus* McDaniel, 1962; *Ferrisiana setosus* (Ali, 1970a).
Common name(s)	Striped mealybug

`Main hosts	*Ferrisia virgata* is one of the most highly polyphagous mealybugs known, attacking plant species belonging to some 160 genera in over 70 families (Ben-Dov *et al.* 2006; CAB International 2007). Many of the host species belong to the Leguminosae and Euphorbiaceae families. Among the hosts of economic importance are: *Anacardium occidentale* (cashew), *Ananas comosus* (pineapple), *Annona cherimola* (custard apple), *Brassica oleracea* (cauliflower), *Cajanus cajan* (pigeon pea), *Citrus* spp., *Coffea* spp. (coffee), *Corchorus* sp. (jute), *Elaeis guineensis* (African oil palm), *Glycine max* (soybean), *Gossypium* sp. (cotton), *Litchi chinensis* (lychee), *Lycopersicon esculentum* (tomato), *Mangifera indica* (mango), *Manihot esculenta* (cassava, tapioca), *Musa* × *paradisiaca* (banana), *Persea americana* (avocado), *Piper nigrum* (black pepper), *Psidium guajava* (guava), *Solanum melongena* (aubergine, eggplant), *Theobroma cacao* (cocoa) and *Vitis vinifera* (wine grape) (CAB International 2007).
Distribution	*Ferrisia virgata* has spread to all zoogeographical regions, mainly in the tropics, but often extends well into the temperate regions (CAB International 2007). It is widely distributed in Africa, Asia, North, Central and South America and Oceania regions. Early geographical records of *F. virgata* need to be verified due to confusion with *F. malvastra* (Ben-Dov 1994). Present in Australia (Ben-Dov *et al.* 2006), not in WA (DAWA 2006). In Asia, *F. virgata* is recorded from Bangladesh, British Indian Ocean Territory, Brunei Darussalam, Cambodia, China (Guangdong, Hong Kong, Taiwan) (CAB International 2007); India (Andhra Pradesh, Goa, Kerala, Orissa, Punjab, Rajasthan, Tripura (CAB International 2007); Assam, Bihar, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh, West Bengal (Ben-Dov *et al.* 2006), Indonesia, Japan, Laos, Malaysia, Myanmar, Pakistan, Philippines, Saudi Arabia, Sinhapore, Sri Lanka, Thailand, United Arab Emirates, Vietnam and Yemen (CAB International 2007).
Quarantine pest	*Planococcus lilacinus* (Cockerell, 1905)
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* (Green); *Planococcus tayabanus* (Cockerell).
Common name(s)	Coffee mealybug
Main hosts	The host range of *P. lilacinus* is extremely wide. It attacks over 65 genera of plants in 35 families, including Anacardiaceae, Asteraceae, Euphorbiaceae, Fabaceae, Leguminosae and Rutaceae (Ben-Dov *et al.* 2006). *Planococcus lilacinus* attacks *Theobroma cacao* (cocoa), *Psidium guajava* (guava), *Coffea* spp. (coffee), *Mangifera indica* (mango) (Ben-Dov *et al.* 2006).
Distribution	*P. lilacinus* occurs mainly in the Palaearctic, Malaysian, Oriental, Australasian and Neotropical regions, and is the dominant cocoa mealybug in Sri Lanka and Java (Entwistle 1972). Williams (1982) reported that the species was probably introduced into the South Pacific from Southern Asia. In Asia, *P. lilacinus* is recorded from Bangladesh, Brunei Darussalam, Cambodia, China, India, Indonesia, Japan, Laos, Malaysia, Maldives, Myanmar, Philippines, Sri Lanka, Taiwan, Thailand, Viet Nam and Yemen (CAB International 2007).
Quarantine pest	*Rastrococcus iceryoides* (Green, 1908a)
Synonyms	*Phenacoccus iceryoides* Green, 1908a; *Dactylopius obtusus* Newstead; *Phenacoccus obtusus* (Newstead, 1911a); *Pseudococcus obtusus* Newstead, 1911a; *Ceroputo iceryoides* (Green, 1908a); *Rastrococcus cappariae* Avasthi & Shafee, 1983; *Parlatoria iceryoides* (Green, 1908a).
Common name(s)	Downey snowline mealybug

Main hosts	*Rastrococcus iceryoides* is one of the most polyphagous species of *Rastrococcus*, occurring on plants belonging to diverse botanical families. It has been recorded attacking over 60 genera of plants in 36 families, including *Mangifera indica* (mango) (Ben-Dov *et al.* 2006; Williams 2004).
Distribution	Williams (1989) notes that *R. iceryoides* is known throughout much of southern Asia and is one of the most widespread species of *Rastrococcus*. It is distributed throughout the Indian region and Malaysia, and has extended its range to East Africa, where it was probably introduced at the beginning of the twentieth century (CAB International 2007). This species is present in Bangladesh, Brunei, China, India (Andaman and Nicobar Islands, Andhra Pradesh, Assam, Bihar, Delhi, Gujarat, Jammu and Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh, West Bengal), Indonesia, Kenya, Malaysia, Malawi, Nepal, Sinhapore, Sri Lanka, Tanzania (Zanzibar), and Thailand (Ben-Dov *et al.* 2006; Luhanga and Gwinner 1993; Williams 1989).
Quarantine pest	*Rastrococcus invadens* Williams, 1986b
Synonyms	None known.
Common name(s)	Mango mealybug
Main hosts	*Rastrococcus invadens* attacks plant species belonging to 48 genera in 27 families, including *Mangifera indica* (mango) (Ben-Dov *et al.* 2006). Agounké *et al.* (1988) listed 45 species of host plants from 22 families attacked by *R. invadens* in West Africa, and Biassangama *et al.* (1991) listed 23 species from Central Africa. Since then, over 100 host-plant species have been found in Africa, particularly where populations of this insect are abundant on the primary host, mango (CAB International 2007)
Distribution	Bangladesh, Benin, Bhutan, China (Hong Kong), Congo, Côte d'Ivoire, Gabon, Ghana, India (Andhra Pradesh, Bihar, Gujarat, Karnataka, Maharashtra, Orissa, Sikkim, Uttar Pradesh) (Ben-Dov *et al.* 2006), Indonesia, Malaysia, Nigeria, Pakistan, Philippines, Sierra Leone, Sinhapore, Sri Lanka, Thailand, Togo, Vietnam (Ben-Dov *et al.* 2006; Williams 2004).
Quarantine pest	*Rastrococcus spinosus* (Roboinson, 1918)
Synonyms	*Phenacoccus spinosus* Robinson, 1918; *Puto spinosus* (Robinson); Ceroputo spinosus (Robinson).
Common name(s)	Philippine mango mealybug
Main hosts	*Anacardium occidentale* (cashew), *Antidesma nitidum*, *Artocarpus altilis* (breadfruit), *Artocarpus heterophyllus* (jackfruit), *Calophyllum* sp., *Citrus* sp.,*Cocos nucifera* (coconut), *Ficus ampelas*, *Garcinia mangostana* (mangosteen), *Heveabrasiliensis* (rubber tree), *Lansium domesticum* (langsat), *Mangifera indica* (mango),*Mangifera odorata* (kuwini), *Nypa fruticans* (mangrove palm), *Plumeria robusta*, *Psidiumguajava* (guava), *Syzygium aqueum* (water apple), *Tabernaemontana* sp. (Ben-Dov *et al.* 2006).
Distribution	Bangladesh, Brunei, India, Indonesia, Cambodia, Laos, Malaysia, Pakistan, Philippines, Sinhapore, Sri Lanka, Taiwan, Thailand, Viet Nam (Ben-Dov *et al.* 2006).
Quarantine pest	*Orgyia postica* (Walker, 1855)
Synonyms	*Lacida postica* (Walker, 1855); *Notolophus australis posticus* Walker; *Notolophus postica* (Walker); *Notolophus posticus* (Walker); *Orgyia ceylanica* Nietner, 1862; *Orgyia ocularis* Moore, 1879; *Orgyia posticus* (Walker) (CAB International 2007).
Common name(s)	Cocoa tussock moth

Main hosts	*Amherstia nobilis*, *Camellia sinensis* (tea), *Cinchona*, *Cinnamomum*, *Coffea* (coffee),*Durio zibethinus* (durian), *Erythrina* spp., *Euphorbia longana* (longan), *Garciniamangostana* (mangosteen), *Glycine max* (soyabean), *Hevea brasiliensis* (rubber), *Lablabpurpureus* (hyacinth bean), *Leucaena leucocephala* (leucaena), *Litchi chinensis* (litchi),*Malpighia glabra* (acerola), *Mangifera indica* (mango), *Nephelium lappaceum* (rambutan),Orchidaceae (orchids), *Populus deltoides* (poplar), *Pyrus communis* (European pear),*Ricinus communis* (castor bean), *Rosa* (roses), *Syzygium cumini* (black plum), *Theobromacacao* (cocoa), *Vigna radiata* (mung bean), *Vitis vinifera* (grapevine), *Ziziphus jujuba* (common jujube) (CAB International 2007).
Distribution	Bangladesh, Brunei Darussalam, China, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Papua New Guinea, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam (CAB International 2007).
Quarantine pest	*Deanolis sublimbalis* Snellen, 1899
Synonyms	*Noorda albizonalis* Hampson, 1903; *Deanolis albizonalis* (Hampson, 1903); *Autocharis albizonalis* (Hampson, 1903)
Common name(s)	Red-banded mango caterpillar
Main hosts	*Mangifera indica* (mango), *Mangifera odorata* (kuwini), *Mangifera minor* (wild mango), *Bouea burmanica* (marian plum) (Waterhouse 1998)
Distribution	*Deanolis sublimbalis* is restricted to Asia and has been recorded in Brunei, China (Yunnan Province), India (Andhra Pradesh, Orissa) (Waterhouse 1998),Indonesia (Java, Sulawesi, Irian Jaya), Myanmar, Papua New Guinea, Philippines and Thailand (Waterhouse 1998).This species is present in Australia but is under official control (QDPIF 2005).
Quarantine pest	*Rhipiphorothrips cruentatus* Hood, 1919
Synonyms	*Rhipiphorothrips karna* Ramakrishnan 1928
Common name(s)	Mango thrips, Grapevine thrips
Main hosts	*Anacardium occidentale* (cashew nut), *Annona squamosa* (sugarapple), *Mangifera indica* (mango), *Psidium guajava* (guava), *Punica granatum* (pomegranate), *Rosa rugosa* (Rugosa rose), *Syzygium cumini* (black plum), *Syzygium samarangense* (water apple or wax apple), *Terminalia catappa* (Sinhapore almond), *Vitis vinifera* (grapevine) (CAB International 2007); *Areca catechu* (areca nut) (More *et al.* 2003); *Jatropha curcas* (Rani and Sridhar 2002); *Eugenia malaccensis* (malay apple) (Wen 1989); *Rosa indica* var. *iceberg* (Aslam *et al* 2001).
Distribution	Afghanistan, Bangladesh, China, India, Myanmar, Oman, Pakistan, Sri Lanka, Taiwan, Thailand (CAB International 2007).
Quarantine pest	*Elsinoe mangiferae* Bitan. & Jenkins
Synonyms	*Sphaceloma mangiferae* [anamorph] Bitanc. & Jenkins
Common name(s)	Mango scab
Main hosts	*Mangifera indica* (mango) (CAB International 2007).
Distribution	Australia (not in WA) (DAWA 2003; Conde *et al*. 2007), Brazil, Canada, China, Cuba, Dominican Republic, Haiti, India, Jamaica, Kenya, Nepal, Panama, Philippines, Puerto Rico, Taiwan, United States of America (CAB International 2007).
Quarantine pest	*Fusarium mangiferae* Britz, M.J., Wingf. and Marasas
Synonyms	N/A

Common name(s)	Mango malformation
Main hosts	*Mangifera indica* L.
Distribution	Present in Egypt, India (Britz *et al.*2002; Ploetz *et al.* 2002) Israel, Malaysia, South Africa and USA. Detected in Australia (Northern Territory) in 2007 and is now under official control (DPIFM 2008)

Appendix C. 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. Our 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[3], 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.

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-

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

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).

There are three groups within the Department primarily responsible for biosecurity and quarantine policy development and implementation:

- Biosecurity Australia conducts risk analyses, including IRAs, and develops recommendations for biosecurity policy as well as providing quarantine advice to the Director of Animal and Plant Quarantine and AQIS
- AQIS 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 and
- Product Integrity, Animal and Plant Health Division (PIAPH) 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. Biosecurity Australia and PIAPH work in partnership with state and territory governments to address regional differences in pest and disease status and risk within Australia, and develop 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, Biosecurity Australia 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. Biosecurity Australia 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 the Environment, Water, Heritage and the Arts (DEWHA) 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 DEWHA directly for further information.

When undertaking risk analyses, Biosecurity Australia consults with DEWHA about environmental issues and may use or refer to DEWHA'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 www.comlaw.gov.au.

International agreements and standards

The process set out in the Import Risk Analysis Handbook 2007 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, Biosecurity Australia:

- 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, and
- assesses the probable extent of the harm that would result.

If the assessed level of quarantine risk exceeds Australia's ALOP, Biosecurity Australia 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 Biosecurity Australia'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. Biosecurity Australia's assessment of risk may also take the form of a non-regulated analysis of existing policy or technical advice to AQIS. Further information on the types of risk analysis is provided in the Import Risk Analysis Handbook 2007.

Glossary

Term or abbreviation	Definition
Absorbed dose rate	Quantity of radiating energy (in gray) absorbed per unit of mass of a specified target (FAO 2007b).
Additional declaration	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information pertinent to the phytosanitary condition of a consignment (FAO 2007b).
Appropriate level of protection	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 2007b).
Biosecurity Australia	A prescribed agency, within the Australian Government Department of Agriculture, Fisheries and Forestry, responsible for recommendations for the development of Australia's biosecurity policy.
Certificate	An official document which attests to the phytosanitary status of any consignment affected by phytosanitary regulations (FAO 2007b).
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 2007b).
Contaminating pest	A pest that is carried by a commodity and, in the case of plants and plant products, does not infest those plants or plant products (FAO 2007b)
Control (of a pest)	suppression, containment or eradication of a pest population (FAO 2007b).
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 2007b).
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 2007b).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2007b).
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2007b).
Fruits and vegetables	A commodity class for fresh parts of plants intended for consumption or processing and not for planting (FAO 2007b).
Host range	Species of plants capable, under natural conditions, of sustaining a specific pest (FAO 2007b).
Import Permit	An official document authorising importation of a commodity in accordance with specified phytosanitary requirements (FAO 2007b).
Import Risk Analysis	An administrative process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2007b).
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 2007b).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used (FAO 2007b).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2007b).
Introduction	The entry of a pest resulting in its establishment (FAO 2007b).
International Standard for Phytosanitary Measures	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 2007b).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment (FAO 2007b).

Term or abbreviation	Definition
Mango fruit waste	May include mango skin, pulp, flesh and/or seed.
Monophagous	Only one known host.
National Plant Protection Organisation	Official service established by a government to discharge the functions specified by the IPPC (FAO 2007b).
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 2007b).
Parasitoid	An insect parasitic only in its immature stages, killing its host in the process of its development , and free living as an adult (FAO 2007b)
Pathway	Any means that allows the entry or spread of a pest (FAO 2007b).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2007b).
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 2007b).
Pest Free Area	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 2007b).
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 2007b).
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 conditions is begin officially maintained (FAO 2007b).
Pest Risk Analysis	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 2007b).
PRA area	Area in relation to which a Pest Risk Analysis is conducted (FAO 2007b).
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 2007a).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2007b).
Phytosanitary Certificate	Certificate patterned after the model certificates of the IPPC (FAO 2007b).
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 2006a)
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 2007b).
Polyphagous	Feeding on a relatively large number of host plants from different plant families.
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 2007b).
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 (FAO 2007b).
Restricted risk	Risk estimate with phytosanitary measure(s) applied
Spread	Expansion of the geographical distribution of a pest within an area (FAO 2007b).
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.
Systems approach(es)	The integration of different pest risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of phytosanitary protection (FAO 2007b).

Term or abbreviation	Definition
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk management measures.

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