Australian Government

Department of Agriculture, Water and the Environment

Final report for the review of biosecurity import requirements for fresh pomegranate whole fruit and processed 'ready-to-eat' arils from India

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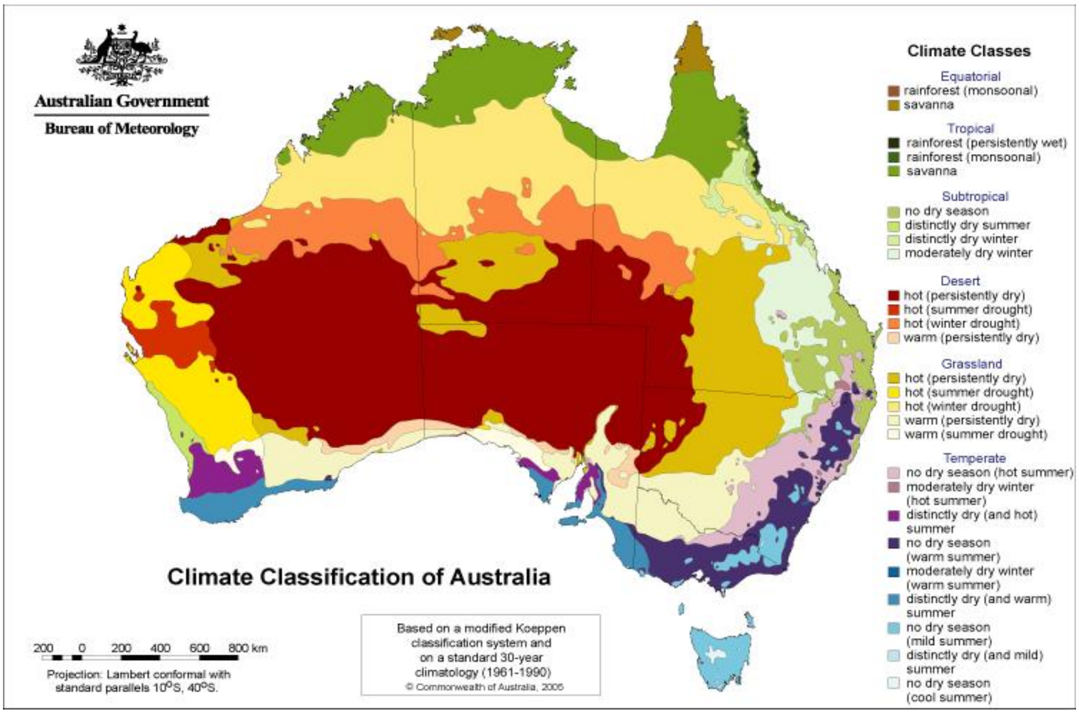


Figure 1 Diagram of pomegranate fruit

Source: Modified from www.zumodegranada.com

Acronyms and abbreviations

Term or abbreviation	Definition
ALOP	Appropriate level of protection
APEDA	Agricultural and Processed Food Products Export Development Authority
BA	Biosecurity Advice
BICON	Australia's Biosecurity Import Conditions System
BIRA	Biosecurity Import Risk Analysis
DAC	Department of Agriculture, Cooperation and Farmers Welfare
EP	Existing policy
EES	Overall likelihood of entry, establishment and spread
ERLs	Extraneous residue limits
FAO	Food and Agriculture Organization of the United Nations
FSANZ	Food Standards Australia New Zealand
FSSAI	Food Standard and Safety Authority of India
Global G.A.P.	The Worldwide Standard for Good Agriculture Practices
GP	Group pest risk analysis
ICAR-NRCP	National Research Centre on Pomegranate
IPM	Integrated pest management
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
MRLs	Maximum residue limits
MSAMB	Maharashtra State Agricultural Marketing Board
NAPPO	North American Plant Protection Organization (Mexico, USA, Canada)
NPPO	National Plant Protection Organisation
NT	Northern Territory
the department	The Department of Agriculture, Water and the Environment
SPS Agreement	WTO agreement on the Application of Sanitary and Phytosanitary Measures
USA	United States of America
WA	Western Australia
WTO	World Trade Organization

Summary

This risk analysis report considers the biosecurity risks for Australia associated with the importation from India of commercially produced fresh pomegranate whole fruit and fresh, processed 'ready-to-eat' arils (hereafter referred to as processed arils) for human consumption.

The assessment for processed arils has been included in this analysis as India has requested market access for both pomegranate whole fruit and processed arils. Additionally, there is data to suggest that processed arils is a pathway for quarantine pests.

Currently, the importation of fresh pomegranate whole fruit for human consumption into Australia is permitted from USA and New Zealand, provided they meet Australia's biosecurity import conditions. Currently, the importation of processed arils is not permitted into Australia.

This final report recommends that the importation of (i) pomegranate whole fruit and (ii) processed arils to Australia from all commercial production areas of India be permitted, subject to them meeting a range of biosecurity requirements, as summarised in this report.

This final report contains details of all known pests with the potential to be associated with the importation of fresh pomegranate whole fruit and processed arils from India that may be of biosecurity concern to Australia. It also provides risk assessments for identified quarantine pests, and recommends risk management measures to reduce the biosecurity risk to an acceptable level.

For fresh pomegranate whole fruit, 13 pests have been identified in this risk analysis as requiring risk management measures. These pests are:

- Fruit flies: carambola fruit fly (*Bactrocera carambolae*), Oriental fruit fly (*Bactrocera dorsalis*), and peach fruit fly (*Bactrocera zonata*)
- Scale insect: almond mealybug (*Drosicha dalbergiae*)
- Mites: pomegranate mite (*Tenuipalpus granati*) and pomegranate false spider mite (*Tenuipalpus punicae*)
- Thrips: western flower thrips (*Frankliniella occidentalis*), chilli thrips (*Scirtothrips dorsalis*), and mangosteen thrips (*Scirtothrips oligochaetus*)
- Mealybugs: grey pineapple mealybug (*Dysmicoccus neobrevipes*), papaya mealybug (*Paracoccus marginatus*), and vine mealybug (*Planococcus ficus*)
- Bacterium: bacterial blight of pomegranate (*Xanthomonas axonopodis* pv. *punicae*).

Two of the thrips species, western flower thrips (*Frankliniella occidentalis*) and chilli thrips (*Scirtothrips dorsalis*), have been assessed as regulated articles as they are capable of harbouring and spreading emerging tospoviruses that are quarantine pests for Australia, and therefore require risk management measures.

The recommended risk management measures take account of regional differences in pest distribution within Australia. One pest requiring risk management measures, western flower thrips (*Frankliniella occidentalis*), has been identified as a regional quarantine pest for the Northern Territory because interstate quarantine regulations and enforcement are in place for this species.

These 13 species are the same, or of the same pest groups, as those associated with other horticultural commodities that have been assessed previously by the department.

This final report recommends a range of risk management measures, combined with an operational system, to ensure biosecurity standards are met. The recommended risk management measures will reduce the risks posed by the 13 identified quarantine pests for whole pomegranate fruit, so as to achieve the appropriate level of protection for Australia (ALOP). These measures are:

- area freedom or fruit treatment (such as cold treatment or irradiation) for fruit flies
- appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action for the scale insect, mites, thrips, and/or mealybugs
- area freedom or a systems approach approved by the Department of Agriculture, Water and the Environment for bacterial blight of pomegranate.

For processed arils, which are a part of the pomegranate fruit, three pests have been identified in this risk analysis as requiring risk management measures. These pests are:

- Fruit flies: carambola fruit fly (*Bactrocera carambolae*), Oriental fruit fly (*Bactrocera dorsalis*), and peach fruit fly (*Bactrocera zonata*).

This final report recommends area freedom, a systems approach approved by the Department of Agriculture, Water and the Environment or fruit treatment (such as irradiation) to reduce the risks posed by the three quarantine fruit fly pests for processed arils, so as to achieve the appropriate level of protection for Australia.

Processed arils must also comply with Australia's food safety requirements to ensure that any food safety hazards associated with the production and processing of pomegranate arils are appropriately managed. Information on food safety requirements is outlined in Section 5.5: 'Meeting Australia's food laws'.

Upon finalisation of this policy, India must be able to demonstrate to the Department of Agriculture, Water and the Environment that processes and procedures are in place to implement the recommended risk management measures. This will ensure safe trade in fresh pomegranate whole fruit and/or processed arils from India. Import conditions can then be published in the Australian Government's Biosecurity Import Conditions (BICON) system on the department's website, which can be accessed at https://bicon.agriculture.gov.au/BiconWeb4.0.

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

- Minor amendments to Chapter 3: 'India's commercial production practices for pomegranate whole fruit and processed arils', to clarify the production and processing steps for commercially produced pomegranate whole fruit and processed arils.
- Amendments to Chapter 4: 'Pest risk assessments for quarantine pests', and elsewhere as appropriate, following a review of the risk assessments for *Deudorix epijarbas*, cornelian butterfly and *Deudorix isocrates*, pomegranate butterfly (Section 4.2), *Aphis punicae*, pomegranate aphid (Section 4.3), *Drosicha dalbergiae*, almond mealybug

(Section 4.4), *Tenuipalpus granati*, pomegranate mite and *Tenuipalpus punicae,* pomegranate false spider mite (Section 4.5), *Coleophoma empetri,* ripe rot (Section 4.11), and *Elsinoë punicae,* pomegranate scab (Section 4.12). Where appropriate, changes were made to the likelihood assessments of importation, distribution, establishment and/or spread, and the potential consequence assessment. The outcome of the review resulted in a change to the unrestricted risk estimate for *A. punicae*, which continued to be assessed as achieving the ALOP. Further assessment of *Cenopalpus pulcher* indicated that the pest is unlikely to be on the pathway and therefore did not require risk assessment; accordingly it has been removed from Chapter 4.

- Amendments to Appendix A-1: 'Initiation and categorisation for pests of pomegranate whole fruit from India' and 'Appendix A-2: Pests of pomegranate fruit that are assessed for pomegranate processed arils from India for human consumption', and elsewhere as appropriate, following a review of the primary elements of the pest categorisation assessment to identify the quarantine pests that require further assessment.

  In addition, re-examination of draft pest categorisation has resulted in eight pests now being considered as present within Australia, three pests as not being on the pathway and one pest as unlikely to establish and spread in Australia. Additional information and references have been included in Appendix A-1 where appropriate to support the outcomes of the review.

- Addition of 'Appendix B: Issues raised in stakeholder comments', which summarises the key technical issues raised by stakeholders, and how they were considered by the department.

- Minor corrections, rewording and editorial changes for consistency, accuracy, clarity and web-accessibility.

1 Introduction

1.1 Australia's biosecurity policy framework

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

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

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

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

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

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

1.2 This risk analysis

1.2.1 Background

India's national plant protection organisation (NPPO), the Department of Agriculture, Cooperation and Farmers Welfare (DAC), Directorate of Plant Protection, Quarantine and Storage (Ministry of Agriculture and Farmers Welfare), in a submission received in February 2017, formally requested market access to Australia for fresh pomegranate whole fruit and processed arils for human consumption. This submission included information on the pests that are associated with commercial pomegranate fruit crops in India, including the plant part(s) affected. Information was also provided on the standard commercial production practices for fresh pomegranate whole fruit grown in India and processed arils for export.

On 31 July 2018, the department announced the commencement of a risk analysis for fresh pomegranate fruit from India, advising that it would be progressed as a review of biosecurity import requirements. This analysis has been conducted in accordance with the *Biosecurity Act 2015*.

India also requested market access for processed arils. As the arils are part of the pomegranate fruit, a decision was made to include the assessment for processed arils as part of the fresh whole pomegranate fruit risk analysis.

In September 2018, officers from the department visited pomegranate production areas in India. The objective of the visit was to observe commercial production, pest management and other export practices of fresh pomegranate whole fruit and processed arils.

1.2.2 Scope

The scope of this risk analysis is to consider the biosecurity risk that may be associated with the pathway of fresh pomegranate (*Punica granatum*) whole fruit and fresh processed 'ready-to-eat' arils produced from pomegranate fruit grown in India, using standard commercial production, processing and packing procedures (as described in Chapter 3: India's commercial production practices for pomegranate whole fruit and arils), for import into Australia, for human consumption.

In this risk analysis, fresh pomegranate whole fruit is defined as the entire fruit with the rind including calyx, mesocarp, arils (seeds) and a small portion of the stem (Figure 1). Fresh arils are defined as the fleshy and usually brightly coloured and edible covering and seed, found inside the pomegranate whole fruit.

This risk analysis assesses commercially produced pomegranate fruit of all cultivars from all production regions of India in which they are grown for export.

1.2.3 Existing policy

International policy

Processed pomegranate arils for human consumption have not previously been assessed for import into Australia.

Import policy exists for fresh pomegranate whole fruit from the USA and New Zealand. Australia also has biosecurity import conditions for Indian horticultural commodities including table grapes (Australian Government Department of Agriculture and Water Resources 2016) and mango (Biosecurity Australia 2008). The potential pests of biosecurity concern for pomegranate fruit from India are the same as, or similar to, pests that have been assessed previously by the department in risk analyses for Indian horticultural commodities and other horticultural commodities, for which import conditions already exist.

The import requirements for these commodity pathways can be found at the department's Biosecurity Import Conditions (BICON) system on the department's website at https://bicon.agriculture.gov.au/BiconWeb4.0

The department has considered all the pests and pest groups previously identified in existing policies and, where relevant, the information in those assessments has been taken into account in this risk analysis. The department has reviewed the latest literature to ensure that information used in previous assessments is still valid.

The biosecurity risk posed by thrips, and the tospoviruses they transmit, from all countries was previously assessed in the *Final group pest risk analysis for thrips and orthotospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (Australian Government Department of Agriculture and Water Resources 2017) (thrips Group PRA).

Similarly, the biosecurity risk posed by mealybugs and the viruses they transmit, from all countries, was previously assessed in the *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (Department of Agriculture and Water Resources 2019a) (mealybugs Group PRA).

These group pest risk analyses are applicable to pomegranate fruit from India. The department has determined that the information in those previous assessments can be adopted for the species under consideration in this risk analysis.

Domestic arrangements

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

1.2.4 Contaminating pests

In addition to the pests of pomegranate from India that are assessed in this risk analysis, there are other organisms that may arrive with the imported commodity. These organisms may include pests considered not to be associated with the fruit pathway, pests of other crops, or predators and parasitoids of other arthropods. The department considers these organisms to be contaminating pests (‘contaminants’) that could pose sanitary risks (to human or animal life or health) or phytosanitary risks (to plant life or health). These risks are identified and addressed using existing operational procedures that require a 600 unit inspection of all consignments on arrival, or equivalent procedures. The department will investigate whether any pest identified through these processes may be of biosecurity concern to Australia, and may thus require remedial action.

1.2.5 Consultation

On 31 July 2018, the department notified stakeholders, in Biosecurity Advice 2018/16, of the commencement of a review of biosecurity import requirements for pomegranate whole fruit and processed ‘ready-to-eat’ arils from India.

Prior to, and after the announcement of this risk analysis, the department engaged with the Australian pomegranate growers regarding the process and technical aspects of this risk analysis.

The department has also consulted with the Indian Government, as well as with Australian state and territory governments during the preparation of this report.

The draft report was released on 18 October 2019 (Plant Biosecurity Advice 2019-P13) for comment by stakeholders, for a consultation period of 60 calendar days that concluded on 17 December 2019.

The department received nine written submissions on the draft report. All submissions received, and technical issues raised by stakeholders throughout the risk analysis process, were carefully considered, and, where relevant, changes were made in this final report. A summary of key technical stakeholder comments and how they were considered is provided in Appendix B.

1.2.6 Next Steps

The final report will be published on the department's website, with a notice advising stakeholders of its release. The department will also notify India, registered stakeholders and the World Trade Organization (WTO) Secretariat of the release of the final report. Publication of the final report represents the end of the risk analysis process.

Before any trade in pomegranate whole fruit and/or processed arils commences, the department will verify that India can implement the required pest risk management measures, and the systems of operational procedures necessary to maintain and verify the phytosanitary status of pomegranate whole fruit and processed arils for export to Australia (as specified in Chapter 5: 'Pest risk management' of this report). On verification of these requirements, the import conditions for pomegranate whole fruit and processed arils will be published in the department's Biosecurity Import Conditions (BICON) system.

2 Method for pest risk analysis

This chapter sets out the method used for the pest risk analysis (PRA) in this report. The Department of Agriculture, Water and the Environment has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2019a) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2019c) that have been developed under the Sanitary and Phytosanitary (SPS) Agreement (WTO 1995b).

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

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

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

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

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

Group Pest Risk Analyses (Group PRAs) have been applied in this risk analysis, as explained in Section 2.2.7.

2.1 Stage 1 Initiation

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

Appendix A-1 and Appendix A-2 of this risk analysis report lists the pests with the potential to be associated with the exported commodity produced using commercial production and packing procedures. Appendix A-1 and Appendix A-2 do not present a comprehensive list of all the pests associated with the entire plant, but concentrates on the pests that could be on the assessed commodity. Contaminating pests that have no specific relation to the commodity or the export pathway have not been listed and would be addressed by Australia's current approach to contaminating pests.

The identity of the pests is given in Appendix A-1 and Appendix A-2. The species name is used in most instances but a lower taxonomic level is used where appropriate. Synonyms are provided where the current scientific name differs from that provided by the exporting country's National

Plant Protection Organisation (NPPO) or where the cited literature used a different scientific name.

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

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

Two Group Pest Risk Analyses (Group PRAs) have been applied in this risk analysis, as explained in Section 2.2.7.

2.2 Stage 2 Pest risk assessment

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

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

2.2.1 Pest categorisation

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

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

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

The results of pest categorisation are set out in Appendix A-1 and Appendix A-2. The quarantine pests identified during categorisation were carried forward for pest risk assessment and are listed in Table 4.1.

2.2.2 Assessment of the probability of entry, establishment and spread

Details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11 (FAO 2019c). The SPS Agreement (WTO 1995a) uses the term 'likelihood' rather than 'probability' for these estimates. In qualitative PRAs, the department uses the term 'likelihood' for the descriptors it uses for its estimates of likelihood of entry, establishment and spread. The use of the term 'probability' is limited to the direct quotation of ISPM definitions.

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

Likelihood of entry

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

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

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

Likelihood of importation—the likelihood that a pest will arrive in Australia when a given commodity is imported.

Likelihood of distribution—the likelihood that the pest will be distributed, as a result of the processing, sale or disposal of the commodity, in the PRA area and subsequently transfer to a susceptible part of a host.

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

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

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

- commercial procedures (for example, refrigeration) applied to consignments during distribution in Australia
- dispersal mechanisms of the pest, including vectors, to allow movement from the pathway to a host
- whether the imported commodity is to be sent to a few or many destination points in the PRA area
- proximity of entry, transit and destination points to hosts
- time of year at which import takes place
- intended use of the commodity (for example, for planting, processing or consumption)
- risks from by-products and waste.

Likelihood of establishment

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

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

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

Likelihood of spread

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

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

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

Assigning likelihoods for entry, establishment and spread

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

Table 2.1 Nomenclature of likelihoods

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

Combining likelihoods

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

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

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

Table 2.2 Matrix of rules for combining likelihoods

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

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.

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

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 the department's method that uses the estimated volume of one year's trade are consistent with Australia's policy on appropriate level of protection and meet the Australian Government's requirement for ongoing quarantine protection. If there are substantial changes in the volume and nature of the trade in specific commodities then the department will review the risk analysis and, if necessary, provide updated policy advice.

In assessing the volume of trade in this risk analysis, the department 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 potential consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing potential consequences are given in Article 5.3 of the SPS Agreement (WTO 1995b), ISPM 5 (FAO 2019b) and ISPM 11 (FAO 2019c).

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

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

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

- eradication, control
- domestic trade
- international trade
- non-commercial and environmental.

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

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

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

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

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

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

Indiscernible—pest impact unlikely to be noticeable.

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

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

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

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

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

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

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

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

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

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

2.2.4 Estimation of the unrestricted risk

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

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

Table 2.5 Risk estimation matrix

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

2.2.5 The appropriate level of protection (ALOP) for Australia

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

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

2.2.6 Adoption of outcomes from previous assessments

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

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

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

2.2.7 Application of Group PRA

Risk estimates derived from a Group PRA are 'indicative' in character. This is because the likelihood of entry (the combined likelihoods of importation and distribution) can be influenced by a range of pathway-specific factors, as explained in Section 2.2.6. Therefore, the indicative likelihood of entry from a Group PRA needs to be verified on a case-by-case basis.

In contrast, and as noted in Section 2.2.6, the risk factors considered in the likelihoods of establishment and spread, and the potential consequences associated with a pest species are not pathway-specific, and are therefore comparable across all import pathways within the scope of the Group PRA. This is because at these latter stages of the risk analysis the pest is assumed to have already found a host within Australia at or beyond its point of entry. Therefore, a Group PRA assessment can be applied as the default outcome for any pest species on a plant import pathway once the previously assigned likelihood of entry has been verified.

In a scenario where the likelihood of entry for a pest species on a commodity is assessed as different to the indicative estimate, the Group PRA-derived likelihoods of establishment and spread and the estimate of consequences can still be used, but the overall risk rating may change.

Group PRAs that were applied to this risk analysis are:

- The *Final group pest risk analysis for thrips and orthotospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (Australian Government Department of Agriculture and Water Resources 2017), which is referred to as the 'thrips Group PRA'.
- The *Final group pest risk analysis for mealybugs*, and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports (Department of Agriculture and Water Resources 2019a), which is referred to as the 'mealybugs Group PRA'.

2.3 Stage 3 Pest risk management

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

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

ISPM 11 (FAO 2019c) provides details on the identification and selection of appropriate risk management options and notes that the choice of measures should be based on their effectiveness in reducing the likelihood of entry of the pest.

Examples given of measures commonly applied to traded commodities include:

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

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

3 India's commercial production practices for pomegranate whole fruit and processed arils

This chapter provides information on the pre-harvest, harvest and post-harvest practices considered to be standard in India for the commercial production of pomegranate whole fruit and processed arils for export. The export capability of India is also outlined.

3.1 Assumptions used in estimating unrestricted risk

India provided Australia with information on the standard commercial practices used in different regions of India for the production of pomegranate whole fruit and processed arils. This information has been supplemented with data from other sources, such as published literature, and was taken into consideration when estimating the unrestricted risks of pests that may be associated with the import of this commodity.

Officers from the Department of Agriculture, Water and the Environment visited pomegranate orchards, packing houses and treatment facilities in the Indian state of Maharashtra in September 2018. Maharashtra is India's major pomegranate producing state, accounting for approximately 66% of total pomegranate production. The objective of the visit was to observe commercial production, pest management and other export practices. The observations during the visit and additional information provided confirmed the production and processing procedures described in this chapter as standard commercial production practices for pomegranate whole fruit and processed arils for export from India.

In estimating the likelihood of pest introduction to Australia, it has been assumed that the pre-harvest, harvest and post-harvest production practices for pomegranate whole fruit and processed arils, as described in this chapter, are implemented for all regions and for all pomegranate varieties. Where a specific practice described in this chapter has not been used to estimate the unrestricted risk, it is clearly identified and explained in Chapter 4.

3.2 Pomegranate production areas

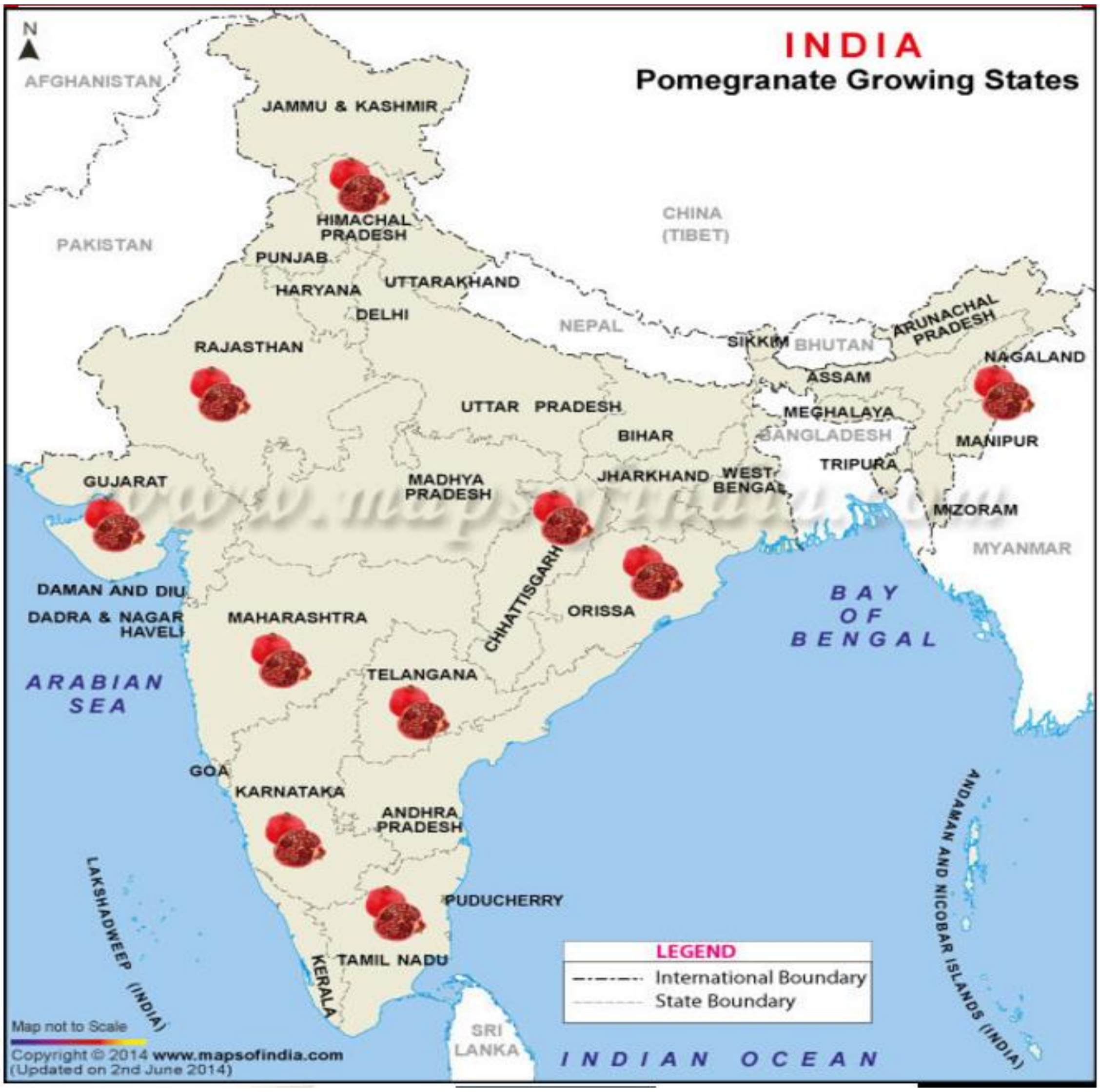
The main pomegranate producing states in India are:

- Maharashtra (predominantly in the Solapur, Nashik, Sangli, Satara, Ahmednagar and Pune districts)
- Karnataka (in the Bijapur, Bagalkot, Koppal, Belgaum, Gadag, Bellary, Raichur, Tumkur, Chitradurg and Davanagere districts)
- Gujarat (the Kutch, Banaskantha, Ahmedabad, Sabarkantha and Bhavnagar districts)
- Andhra Pradesh (the Anantpur district)
- Telangana (the Mahabubnagar district)
- Tamil Nadu (the Salem, Coimbatore and Periyakulam districts)
- Rajasthan (the Hanumangarh and Ganganagar districts) and
- Himachal Pradesh (the Solan, Kullu, Sirmour districts) (Government of India 2017a; Jain & Desai 2018).

Although other states including Orissa, Nagaland and Chattisgarh produce pomegranate, they are not major contributors to the export of pomegranate from India. The pomegranate production states are shown in Map 3.

In 2015–16, the total area under pomegranate production was 196,890 hectares (Government of India 2017a). Of this total area, 70.2% was situated in Maharashtra (Jain & Desai 2018).

Map 3 India's pomegranate production states



Source: https://www.mapsofindia.com/indiaagriculture/fruits-map/pomegranate-producing-states.html

3.3 Climate in production areas

Pomegranate prefers hot summers and cold winters, although it can adapt and grow in other climates (Kahramanoglu & Usanmaz 2016). Pomegranate is drought tolerant and grows well in arid and semi-arid areas (Galindo et al. 2014; Ghosh 2013).

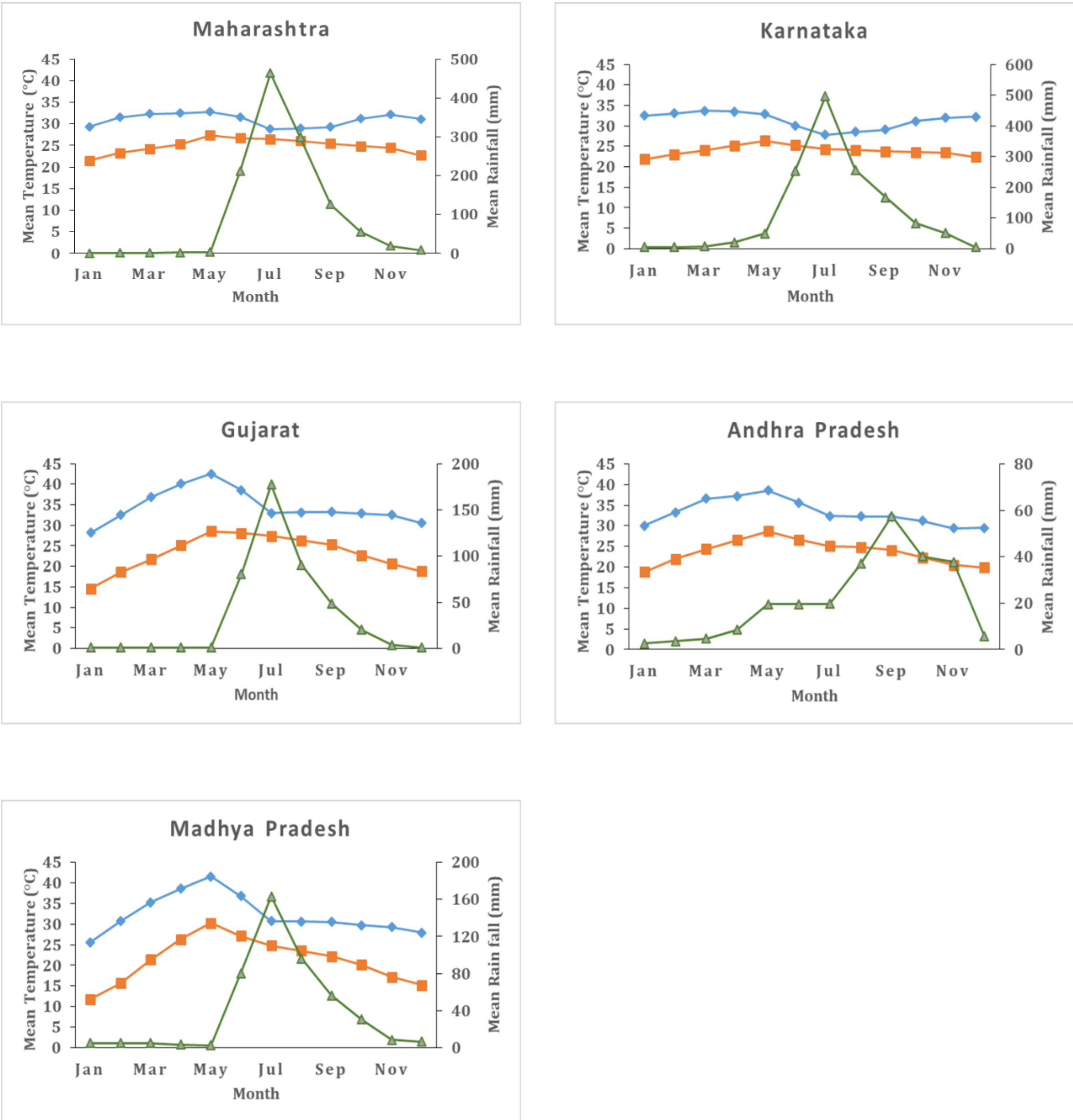
India has four major climate regions: Subtropical Savanna in the north, Tropical and Subtropical Steppe in the centre and extending to the south, Tropical Rainforest in the west and extending to the south, and Tropical Savanna in the east. The southern part of India has a combination of Tropical Rainforest to the west and Tropical and Subtropical Steppe to the east (Goode's World Atlas 2005).

Four seasons are experienced in India: Winter (January–February), with average temperatures of 10°C to15°C in the northwest and 20°C to 25°C in the southeast; Summer (March–June), considered the pre-monsoon season with thunderstorms and high temperatures reaching up to 40°C in central India; Rainy (July–September), considered the southwest summer monsoon season with approximately 75% of India's annual rainfall, and Autumn (October–December), considered the northeast winter monsoon season with the northeast receiving approximately 35% of its annual rainfall (Dash et al. 2007; Maps of India 2018). However, due to the large geographic range of India along both the north-south and west-east axes, different parts of the country experience different ranges of temperature and rainfall even during the same month or season.

The Deccan Plateau, covering most of southern India, provides an optimal climate for pomegranate and allows for staggered year-round production (Chandra, Jadhav & Sharma 2010). The climate of the Deccan Plateau varies from semi-arid to tropical in most of the region with distinct wet and dry seasons. The plateau receives rainfall from June to October in the monsoon season up to about 700mm. The summer period, from March to June, is hot with temperature averaging at about 28°C and can reach a maximum of 40°C.

Figure 2 summarises the annual minimum and maximum temperatures, and mean rainfall in major pomegranate producing states in India.

Figure 2 Minimum and maximum temperatures and mean monthly rainfall in the main pomegranate production areas of India



Monthly mean maximum (-♦-) and minimum (-■-) temperature (°C) and mean monthly rainfall (millimetres) (-▲-) from climatic data collected between 2009 and 2018 (World Weather Online 2019) in India's major pomegranate production areas of Maharashtra, Karnataka, Gujarat, Andhra Pradesh and Madhya Pradesh.

3.4 Pre-harvest

3.4.1 Cultivars

India grows a large number of pomegranate cultivars, which exhibit differing growth characteristics and fruit quality attributes, including fruit size, colour, shape, seed hardness, taste and flavour (Verma, Mohanty & Lal 2010). Most Indian pomegranate varieties that are grown in hot climates are considered 'sweet' and have low acidity levels (Mayuoni-Kirshinbaum & Porat 2014). Major pomegranate varieties cultivated in India are Bhagwa, Ganesh, Arakta, Mridula and Ruby. Other varieties grown in India include Alandi or Vedki, Kandhari, Kabul, Dholka, Paper Shelled, and Muskati Red (Confederation of Indian Industry 2014; Government of India 2017a; Verma, Mohanty & Lal 2010).

Varietal characteristics of the most common commercially grown pomegranates in India are presented in Table 3.1. The key pomegranate producing states and the major cultivars grown in those states are given in Table 3.2.

Table 3.1 Main commercial pomegranate varieties cultivated in India

Variety	Characteristics
Bhagwa	Popular variety in Maharashtra (Phule 2002) and Karnataka (Shiva Prasad et al. 2012; Vasanth Kumar 2009). It is a large size fruit with blood-red rind and red arils, soft seeds (Hiwale 2009) and sweet taste (Hiwale 2009).
Ganesh	Popular variety in Maharashtra and Karnataka (Shiva Prasad et al. 2012; Vasanth Kumar 2009). It is a medium size fruit with yellow-pink rind, pink-red arils, very soft seeds and sweet/sour taste.
Ruby	Popular variety in Karnataka (Shiva Prasad et al. 2012; Vasanth Kumar 2009) and Andhra Pradesh (Phule 2002). It is a small/medium size fruit with red rind, red arils (Hiwale 2009), and soft seed (Hiwale 2009).
Arakta	Popular variety in Maharashtra (Phule 2002) and Karnataka (Shiva Prasad et al. 2012; Vasanth Kumar 2009). It is a large size fruit with deep-red rind, deep-pink to blood-red arils, hard seeds and sweet/sour taste.
Mridula	Popular variety in Maharashtra (Sharma et al. 2014). It is a medium size fruit with dark red rind, blood-red arils, soft seeds and sweet taste.

Table 3.2 Key pomegranate growing states and major pomegranate varieties cultivated in India

State	Varieties
Andhra Pradesh	Bhagwa, Ruby
Gujarat	Bhagwa, Dholka
Himachal Pradesh	Bhagwa, Ganesh
Jammu & Kashmir	Bhagwa, Ganesh, Kandhari
Karnataka	Bhagwa, Ruby, Jyoti
Madhya Pradesh	Bhagwa, Ganesh
Maharashtra	Bhagwa, Ganesh, Arakta, Mridula
Rajasthan	Jalore Seedless, Jodhpur Red
Tamil Nadu	Bhagwa, Ganesh

3.4.2 Cultivation practices

Planting materials

In India, pomegranate is mainly propagated using cuttings or through air layering. Of these two methods, air layering is reported to be the preferred method in pomegranate-growing areas of the Deccan Plateau (Chandra & Meshram 2010). In-vitro propagation (tissue culture) is another technique used for propagation but it is not widely used at the commercial level.

The technique of air layering is a commonly practised propagation method. It is carried out by girdling upright branches of 0.8cm to 1.5cm diameter for 2cm to 3cm, and treating the upper part of the cut with rooting hormone, indole-3-butric acid (IBA), at a concentration of 2,000ppm to 3,000ppm. The girdled stem is wrapped with sphagnum moss, covered with a small polyethylene strip and tied with a coir/jute thread or string.

Once the layer is well rooted (usually after 75 to 90 days), it is detached from the mother plant at the lower girdle, and planted in the nursery or kept in polythene bags for planting in the orchard.

Another method of propagation is stem cutting, which is used throughout the year using pruned wood in polyhouses under high humidity conditions. Pruned wood that is taken immediately after the rest phase of the pre-monsoon period gives a high rate of propagation success, and therefore is preferred for stem cuttings.

Stem cuttings range from 20cm to 25cm in length and 0.6cm to 1.2cm in thickness. Six to 18-month-old shoots of hardwood (avoiding the lateral shoots), are usually used. The cuttings are disinfected and a root growth inducer is applied, and then it is planted in a mixture of coco peat and sand mixture or coco peat alone. After around 45 to 60 days, the well-rooted cuttings are transferred to nursery bags with a pre-sterilised sand, soil and farmyard manure mixture. The cuttings continue to grow in the nursery bags for a further 45 days and the cuttings are then ready for planting in the field.

Cultivation

Pomegranate grows best under semi-arid/arid conditions, but can adapt to a wide range of climate and soil conditions. Annual rainfall of around 560mm with a long, hot and dry summer and mild winter are suitable for quality fruit production (Sharma et al. 2014). Well-drained soil with a pH range of 6.5 to 7.0 is reported to be most suitable for pomegranate, although it can tolerate a soil pH of up to 8.5.

The young trees are typically planted using a square or rectangular system, where the trees are planted at each corner of the square or rectangle. In general, 4.5m x 3.0m (740 trees/ha) is the optimum planting spacing for varieties such as Bhagwa. However, spacing of 5m x 4m (500 trees/ha) and 5m x 5m (400 trees/ha) can be followed for more spreading varieties such as Ganesh.

Plants are trained on a single or multi-stem system, where four to five well-distributed shoots are allowed to grow (Phule 2002). Ground suckers, water shoots, cross branches and dead or diseased twigs are removed periodically to shape the tree, avoiding overcrowding for enhanced productivity (Government of India 2017a; Phule 2002; Sharma et al. 2014).

Regular irrigation (weekly in summer and fortnightly in winter) is reported to decrease fruit cracking and increase yield (Radha & Mathew 2007). Drip irrigation and bed or basin irrigation are common methods used by pomegranate farmers (Jain & Desai 2018).

Pomegranate plants flower and bear fruit throughout the year in central and southern India (Government of India 2017a). However, in order to obtain higher fruit yield during a specified period, the pomegranate plants are given a resting period during which the natural tendency of the tree is altered with artificial means. This is done by withholding irrigation for about 60 days in advance of normal flowering, root exposure, and use of chemicals, and is known as bahar treatment or flower regulation.

To align with the patterns of precipitation in India, flowering can be induced during June–July (mrig bahar), September–October (hasta bahar) and January–February (ambe bahar). Ambe bahar is adopted in the areas where there is enough water available during hot weather. Mrig bahar usually coincides with the beginning of monsoon and is used in areas where water is scarce during the hot weather. For hasta bahar induced flowering, the trees have to be made dormant during August–September. This can be uncertain to achieve because of rain that occurs during this period, making it difficult to implement. However, hasta bahar has been reported to be the most commonly used practice in pomegranate production (Sachin, Ramteke & Bharath 2015). With the adoption of bahar treatment, pomegranate harvest can be tailored to demand, to allow supply throughout the year (APEDA 2019).

Pomegranate plants start bearing fruit about four years after planting and can have an economic life of 25 to 30 years under good management conditions (Radha & Mathew 2007).

3.4.3 Pest management

Growers follow an integrated pest and disease management system for pomegranate cultivation, that is recommended by the National Research Centre on Pomegranate and the National Institute of Plant Health Management (Satyagopal et al. 2014), to manage a range of pests and diseases that can affect growth and development of pomegranate fruit.

Pest and disease management commences at the propagation stage of pomegranate plants with the sourcing of propagative material from healthy source stock, and the pre-treating of propagative material with appropriate disinfectant.

Agronomic and sanitation procedures are implemented in orchards where pomegranates are commercially produced for export. The agronomic and sanitation procedures are monitored by relevant government authority officials such as agriculture extension officers.

In addition to farm hygiene, nutrient and water management practices are followed as good plant health measures that contribute to prevention and control of pests and diseases (Sharma et al. 2014).

Pomegranate growers regularly monitor orchards for pests and diseases. They are required to advise agriculture extension officers from the relevant government authority of detections of pests and diseases, in order to undertake and monitor appropriate control and/or eradication measures. Insect and fruit fly traps are also used to monitor pests in the orchards. Sticky paper traps are used to monitor for insects. The sticky paper traps are placed at regular intervals throughout the orchard. Methyl eugenol traps are also placed in the orchards when the fruit starts to mature to monitor for fruit flies. Pomegranate orchards are regularly sprayed with chemical pesticides to manage pests and diseases. The chemical pesticides used must be approved by the relevant Indian Government authority. The following is an overview of the pest and disease management practices that are used for commercially produced pomegranate fruit for export (Government of India 2017a; Satyagopal et al. 2014; Sharma et al. 2014):

- appropriate spacing of plants, the planting of resistant or tolerant varieties, and the use of healthy and certified planting material
- appropriate nutrient and water management to promote plant health and help prevent pest and pathogen infestation
- field sanitation, soil solarisation, weed removal, destruction of alternative hosts, and periodic removal and destruction of pest-affected plant parts
- periodic surveillance to detect pest symptoms, and spraying of orchards with recommended chemicals for the management of pests and pathogens
- the use of biological control agents.

The following insecticides and fungicides are applied in order to manage and control arthropod pests and pathogens:

- the insecticide cyantraniliprole 10.26% oil dispersion (OD) at a rate of 0.7mL/L to 0.9mL/L is applied to control mealybugs and lepidopteran pests.
- freshly ground neem (*Azadirachta indica*) seed extract at 50g/L or 3% neem oil is applied at the stage of flowering. Fifteen days after the first spray, a second application of 1,500 ppm azadirachtin (the active ingredient of neem seed) is applied to control fruit borers.

  After flowering period, cyantraniliprole 10.26% (OD) at a rate of 0.7mL/L alternated with neem seed extract, oil, or azadirachtin 1,500ppm are applied, as required to control fruit borers.
- the fungicide, Bordeaux mixture (copper sulphate and calcium hydroxide) 1% is applied at 15-day intervals to control fungal pathogens, including fruit rot causing fungi. If fruit rot is observed, the affected fruit are removed and buried or burnt outside of the orchard. The orchard is then sprayed with other fungicides such as difenoconazole 25% emulsifiable concentrate (EC) at a rate of 0.5mL/L to 1.0mL/L.
- Bordeaux mixture (0.5% or 1% just after the pruning and rest periods), and streptocycline (5g/10L) or 2-bromo, 2-nitro propan-1, 3-diol (5g/10L) mixed with copper-based formulations such as copper oxychloride or copper hydroxide (20-25g/10L) are applied at 10-15 day intervals depending on weather conditions to control pathogens such as bacterial blight.

Orchards registered for exporting pomegranate whole fruit and processed arils maintain records of pest management practices, including pesticide application details, and the other cultivation practices such as fertiliser application and relevant testing results.

3.5 Harvesting and handling procedures

In many states, harvest commences in December–January and extends to June–July, depending on the bahar. Table 3.3 summarises the harvest season of pomegranate in India. Maharashtra and Gujarat produce pomegranate fruit throughout the year, as a number of bahar treatments are adopted in these two states (Sharma et al. 2014).

Table 3.3 Pomegranate harvest pattern in the leading pomegranate growing states in India

STATE/UT'S	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Maharashtra												
Karnataka												
Andhra												
Gujarat												

	Lean Period		Peak Period		All year around

Pomegranate fruit is harvested when the fruit is fully ripe (Radha & Mathew 2007), usually about 120 to 130 days after fruit set and when the rind has developed the typical colour of the cultivar.

Fruit are harvested by clipping the fruit stem with shears (Satyagopal et al. 2014). Harvested fruit are placed in crates and transported to the packing house in covered trucks.

3.6 Post-harvest

After harvest, fruit are transported to packing houses, registered with the Agricultural and Processed Food Products Export Development Authority (APEDA) for the export of pomegranate whole fruit and processed arils. Some packing houses may also be accredited under the Global GAP (the Worldwide Standard for Good Agriculture Practices) program.

Descriptions of the general design, maintenance and operating procedures of registered packing houses are outlined below. Registered packing houses:

- are designed with a layout and work flow practice that allow separation of each processing step, segregation of processed and unprocessed fruit, and use of separate rooms for pre- and post-extraction activities, to minimise the potential for contamination.
- are maintained in a clean and tidy condition, with appropriate pest control measures in place, including fly-proof construction and sticky-paper traps inside/around the packing house.
- have separate rooms for inspection of fruit. Rooms have adequate light and the necessary equipment and pest information to conduct phytosanitary inspection such as posters of fruit with pest damage and symptoms, to differentiate from non-pest/disease related damage such as sunburn, physical damage and damage caused by thorns.
- have guidelines and operating procedures to determine levels of severity at which damaged fruit can proceed to grading/sorting and packaging for export.
- have guidelines and operating procedures for waste management. Designated bins with liners are used for dry and wet waste, and the bins are emptied/removed regularly and waste is disposed of appropriately, in order to minimise the infestation of processed whole fruit.

3.6.1 Packing house processes: whole fruit

Receival and quality check

When whole pomegranate fruit arrive at the packing house, they are checked by the quality assurance team for fruit damage, pests and diseases, abnormal fruit shapes and colour. The team ensures that only export quality fruit proceed for processing. If fruit are infested with pests or show disease symptoms, the entire load of fruit is returned to the farmer and excluded for processing for export markets.

Following an on-arrival quality check, fruit proceed to processing or are temporarily held in cold storage (at around 5°C to 8°C) until fruit processing can commence.

Cleaning

Fruit are washed in large tubs of clean water, which has been treated by reverse osmosis and UV filtration. The fruit are then manually transferred to a second large tub and washed using 'Tsunami™' (acetic acid, peroxyacetic acid and hydrogen peroxide) or a solution of chlorine-based disinfectant (such as hypochlorite). Washing solutions are changed after two washes in manual washing systems and four to five times per day in continuous wash systems.

The whole pomegranate fruit are manually transferred to a cleaning table where each fruit is brushed by hand. The fruit calyx is cleaned using an air gun, which forces air through a fine-tipped nozzle to remove debris and the stamen cluster.

Sorting and grading

Fruit are sorted on large tables and any cracked, split, damaged or bruised fruit are removed and discarded. Fruit are graded based on their weight, size and colour. The different varieties for international markets are classified based on size, weight and appearance, including the presence of physical imperfections such as marks or spots (Indian National Horticulture Board 2019).

Packing

Fruit are packed in labelled cardboard packaging before being stored in cool rooms. Pomegranate fruit are susceptible to moisture loss and need to be stored at low temperature and high humidity. Fruit can be stored for up to ten weeks at 5°C with a relative humidity of 90% to 95%. However, if longer storage is required, the temperature is raised to 10°C to avoid chilling injury and weight loss. Fruit are transported at a temperature of 5°C to 8°C to their destination.

Each box is labelled to identify the orchard/farmer, the farm plot, packing house and date of harvest and packing.

3.6.2 Packing house processes: arils

The processing steps for arils are similar to those for whole fruit, with slight differences in the pre-cleaning process. The extraction and processing of 'ready-to-eat' arils intended for export is conducted in registered packing houses, under controlled environmental conditions.

Receival and quality check

On arrival at the registered packing house, the pomegranate fruit are checked by the quality assurance team for fruit damage and pest and diseases. Damaged fruit are removed and discarded. If fruit are infested with pests or show disease symptoms, the entire load of fruit is returned to the farmer and excluded from processing for export markets.

Cleaning

The stem and calyx of fruit are removed and the fruit is then washed in large tubs of fresh water (Figure 3). Each fruit is hand brushed before being transferred for disinfection using either 'Tsunami™' or a chlorine-based disinfectant. Figure 4 shows cleaned pomegranate whole fruit, with the calyx and stem removed, before the fruit arils are processed.

Figure 3 Packing house—whole fruit washed using 'Tsunami™'

Figure 4 Cleaned pomegranate whole fruit prior to aril extraction

Extraction of arils and screening

Following fruit cleaning and disinfection, the fruit rind is cut vertically and the arils are extracted manually into clean containers.

The arils are then transferred to a slow-moving, white conveyor belt, where the arils are manually screened for contaminants or non-compliant product such as discoloured and/or damaged arils (Figure 5).

Figure 5 Arils screening

Packing

Arils are packed in transparent modified atmosphere packaging (MAP) containers, which are sealed and labelled (Figure 6 and Figure 7). The packed arils are passed through a metal detector to ensure there are no metal contaminants.

Arils can also be packed in bulk packs. Bulk packs are filled with nitrogen and carbon dioxide gas after vacuum processing in order to reduce the likelihood of microbial build-up, and to increase shelf life.

The packed arils are kept in Styrofoam cartons with ice gel packs in order to maintain temperature during transportation to their destination. The packed arils are subject to rapid pre-cooling to 0°C to 4°C, and are then stored at 0°C to 2°C until dispatch (Government of India 2017a).

Samples are taken for food safety testing, and retained for the shelf life of the processed arils.

Figure 6 Processed arils packaging and labelling

Figure 7 Processed arils product

3.6.3 Phytosanitary inspection

The phytosanitary inspection processes for pomegranate whole fruit and processed arils are the same. An Indian Government Phytosanitary Officer inspects the consignment for compliance with the importing country's phytosanitary requirements. The phytosanitary inspection is conducted in the plant quarantine area of the packing house. Inspectors randomly draw samples from the consignment, and inspect the fruit/arils for any pests and diseases. If a sample fails to meet importing country requirements, the whole consignment is rejected and the relevant farmer is informed of the rejection.

A phytosanitary certificate is issued for consignments that pass inspection.

3.6.4 Transport

Processed pomegranate whole fruit and processed arils are loaded into refrigerated vans and dispatched to the port for export. The whole fruit is maintained at 5°C to 8°C and arils at 1°C to 5°C during transit to the importing country.

A schematic diagram summarising the pre-harvest, harvest and processing system for pomegranate whole fruit and processed arils produced in India for export is provided in Figure 8.

3.6.5 India's regulatory framework

The production of plant and plant products for export from India is governed by a regulatory framework implemented by multiple government agencies. The primary agencies involved in regulating the export of pomegranate whole fruit and processed arils, and their respective roles in relation to biosecurity and/or food safety are summarised below.

The Department of Agriculture Cooperation and Farmers Welfare is India's National Plant Protection Organisation. Its roles and responsibilities include:

- inspecting goods for export and issuing phytosanitary certificates
- promoting integrated pest management (IPM) on-farm
- ensuring safe and effective use of chemicals on-farm
- monitoring chemical residue levels at a national scale, particularly for exported goods.

The Food Standard and Safety Authority of India manages food safety issues. Its roles and responsibilities include:

- developing and maintaining food safety standards
- developing and maintaining mechanisms and guidelines for accreditation of bodies engaged in the certification of food businesses
- providing training programs for persons who are involved in food businesses
- promoting general awareness about food safety and food standards.

The Agricultural and Processed Food Products Export Development Authority is primarily focussed on export related matters. Its roles and responsibilities include:

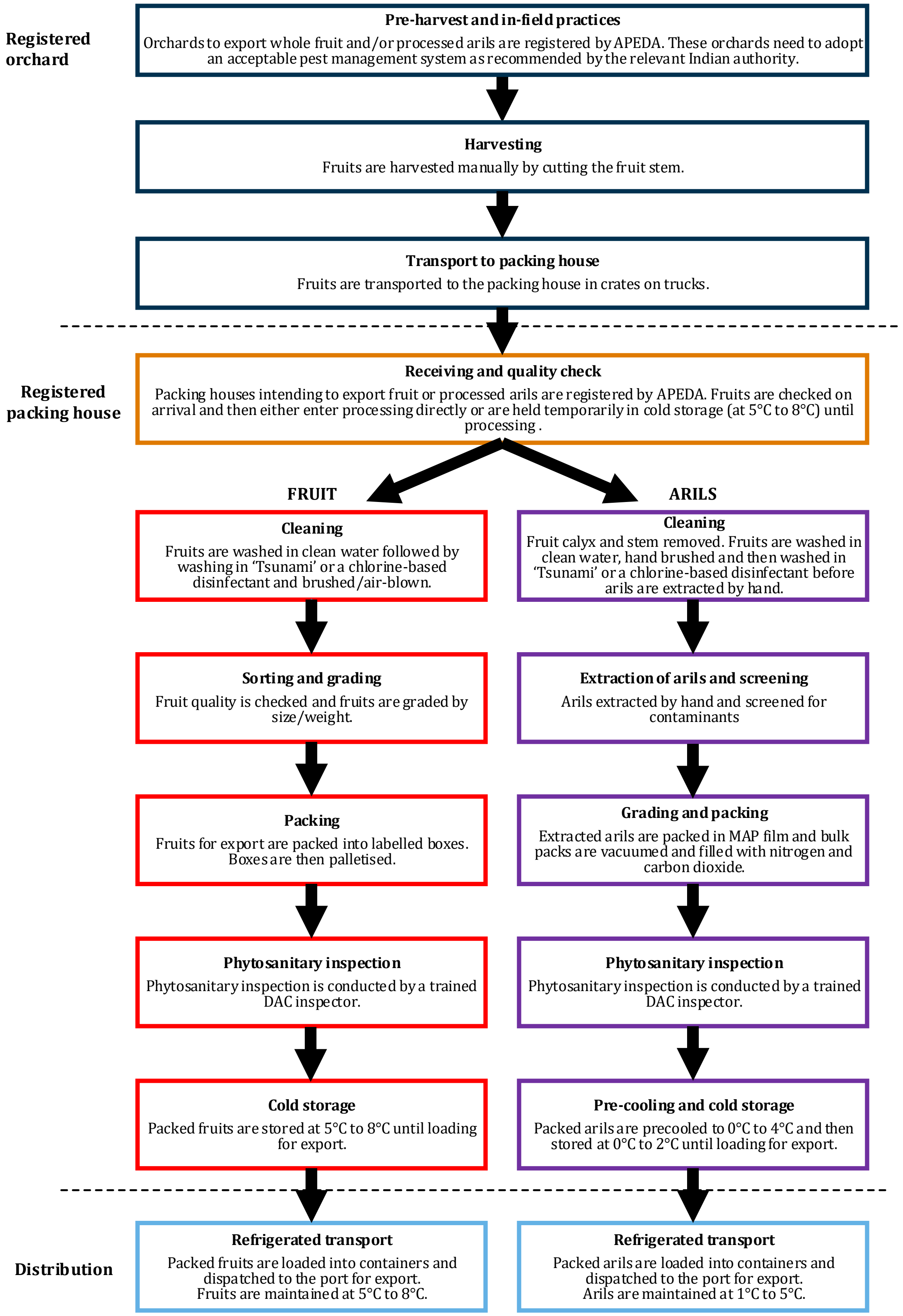
- registering exporters, packing houses and treatment facilities

- setting commodity standards and specifications for exports
- providing training to support export industries
- maintaining the food traceability system.

The State Government Department of Agriculture is primarily responsible for providing on-farm training/assistance to farmers, which include:

- registering orchards for the production of commodities for export
- providing crop management advice to growers
- undertaking chemical residue testing during production
- undertaking food licensing on behalf of the Food Standard and Safety Authority of India.

Figure 8 Summary of orchard and post-harvest steps for pomegranate commodities produced in India for export



3.7 Export capability

3.7.1 Production statistics

India is one of the world's largest producers of pomegranate and produced 1,346,000 tonnes in 2013–2014. India's pomegranate production area has grown from 96,900 hectares in 2003–2004 to 131,000 hectares in 2013–2014 (Government of India 2017a). The leading state for pomegranate production is Maharashtra, followed by Karnataka, Gujarat and Andhra Pradesh (Government of India 2017a). A summary of production statistics for each Indian state in 2013–2014 is provided in Table 3.4.

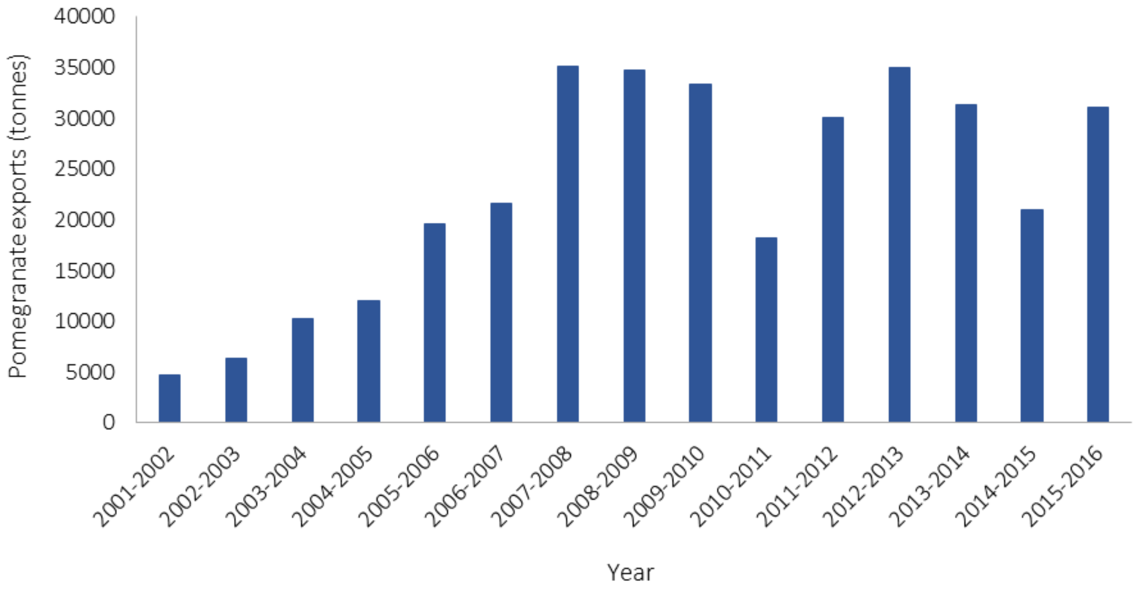
Table 3.4 Area and volume of production of pomegranate in India by state for the financial year 2013–2014 (Government of India 2017a)

State	Area (hectares)	Production (tonnes)
Maharashtra	90,000	945,000
Karnataka	16,620	134,180
Gujarat	9,380	99,330
Andhra Pradesh	6,000	90,010
Telangana	1,730	25,970
Madhya Pradesh	2,380	25,290
Tamil Nadu	400	13,090
Rajasthan	910	5,630
Himachal Pradesh	2,200	2,540
Odisha	230	870
Nagaland	120	730
Chhattisgarh	140	510
Mizoram	10	20
Andaman	10	-
Total	131,000	1,346,000

3.7.2 Export statistics

India exports pomegranate products to over 45 countries around the world (Jain & Desai 2018). The major export markets include Bangladesh, Kuwait, Saudi Arabia, the Netherlands, the United Kingdom and United Arab Emirates (Government of India 2017a; Jain & Desai 2018). Of the 1,346,000 tonnes of whole pomegranate fruit produced in India in the 2013–2014 financial year, only a small proportion (31,328 tonnes) was exported to international markets (Government of India 2017a). A summary of India's pomegranate whole fresh fruit exports from 2001–2016 is presented in Figure 9.

Figure 9 India's pomegranate exports from 2001–2016



3.7.3 Export season

Due to India's favourable climate, pomegranate fruit can be produced all year round (Jain & Desai 2018) through induced flowering techniques. The peak production season of pomegranate in India is from December to March but can continue through to June/July (Government of India 2017a). Although it is expected that exports to Australia would primarily occur during the peak production period, there is a possibility that exports could occur throughout the year as pomegranate fruit can be produced all year round in India.

4 Pest risk assessments for quarantine pests

A total of 20 pests, which includes regulated thrips (Table 4.1) potentially associated with commercially produced, export-quality pomegranate whole fruit produced in India were identified in the pest categorisation process (Appendix A-1: Initiation and categorisation for pests of pomegranate whole fruit from India).

Of these 20 pests, five species were identified as potentially associated with pomegranate processed arils from India (Appendix A-2: Pests of pomegranate fruit that are assessed for pomegranate arils from India for human consumption). Table 4.1 summarises the quarantine pests associated with the commercially produced, export-quality pomegranate whole fruit and processed arils from India pathways.

This chapter assesses the likelihoods of the entry (importation and distribution), establishment and spread of these pests, and the economic, including environmental, consequences these pests may have if they were to enter, establish and spread in Australia.

Two pests, *Frankliniella occidentalis* and *Deudorix epijarbas*, identified in this assessment, have been recorded in some regions of Australia and, due to interstate quarantine regulations and their enforcement, are considered pests of regional concern. The acronyms for the state and territory for which the regional pest status is considered, 'WA' (Western Australia) and 'NT' (Northern Territory), are used in conjunction with identities of these pests.

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

The biosecurity risk posed by thrips, and the tospoviruses they transmit, from all countries was previously assessed in the *Final group pest risk analysis for thrips and orthotospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (Australian Government Department of Agriculture and Water Resources 2017). Similarly, the biosecurity risk posed by mealybugs, and the viruses they transmit, from all countries was previously assessed in the *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports* (Department of Agriculture and Water Resources 2019a). These Group PRAs have been applied to this assessment of pomegranate whole fruit from India.

The acronym 'GP' is used to identify species assessed previously in a Group PRA and for which a Group PRA is applied. The method of application of the Group PRAs to this risk analysis is outlined in Section 2.2.7. A summary of assessment from the Group PRA is presented for the relevant pests and regulated thrips in this chapter for convenience.

Table 4.1 Quarantine pests associated with pomegranate whole fruit and processed arils from India

Pest	Common name	Present on fruit pathway	Present on processed arils pathway
Fruit flies [Diptera: Tephridae]			
Bactrocera carambolae (EP)	carambola fruit fly	Yes	Yes
Bactrocera dorsalis (EP)	Oriental fruit fly	Yes	Yes
Bactrocera zonata (EP)	peach fruit fly	Yes	Yes
Fruit borers [Lepidoptera: Lycaenidae]			
Deudorix epijarbas (EP, WA)	cornelian butterfly	Yes	Yes
Deudorix isocrates	pomegranate butterfly	Yes	Yes
Aphid [Hemiptera: Aphididae]			
Aphis punicae	pomegranate aphid	Yes	No
Scale insect [Hemiptera: Monophlebidae]			
Drosicha dalbergiae	almond mealybug	Yes	No
Mites [Trombidiformes: Tenuipalpidae]			
Tenuipalpus granati	pomegranate mite	Yes	No
Tenuipalpus punicae	pomegranate false spider mite	Yes	No
Thrips [Thysanoptera: Thripidae]			
Frankliniella occidentalis (GP, RA, NT)	western flower thrips	Yes	No
Scirtothrips dorsalis (GP, RA)	chilli thrips	Yes	No
Scirtothrips oligochaetus (GP)	mangosteen thrips	Yes	No
Mealybugs [Hemiptera: Pseudococcidae]			
Dysmicoccus neobrevipes (GP)	annona mealybug	Yes	No
Paracoccus marginatus (GP)	papaya mealybug	Yes	No
Planococcus ficus (GP)	vine mealybug	Yes	No
Moth [Lepidoptera: Pyralidae]			
Cryptoblabes gnidiella (EP)	honeydew moth	Yes	No
Bacterium [Xanthomonadales: Xanthomonadaceae]			
Xanthomonas axonopodis pv. *punicae*	bacterial blight of pomegranate	Yes	No
Fungi			
Pseudocercospora punicae	cercospora fruit spot	Yes	No
Coleophoma empetri	pipe rot	Yes	No
Elsinoë punicae	pomegranate scab	Yes	No

EP: Species has been assessed previously and import policy already exists. **GP:** Species has been assessed previously in a Group PRA (thrips Group PRA or mealybugs Group PRA) and the Group PRA has been applied. **WA:** Pest of biosecurity concern for Western Australia. **NT:** Pest of biosecurity concern for the Northern Territory. **RA:** regulated article, refer to Section 4.6 for definition of a regulated article.

4.1 Carambolae fruit fly, Oriental fruit fly and Peach fruit fly

***Bactrocera carambolae* (EP), *Bactrocera dorsalis* (EP) and *Bactrocera zonata* (EP)**

Fruit flies *Bactrocera carambolae* (carambola fruit fly), *B. dorsalis* (Oriental fruit fly), and *B. zonata* (peach fruit fly) belong to the Tephritidae or 'fruit fly' family (White & Elson-Harris 1992). The three species have been grouped together in this assessment because of their related biologies and taxonomies, on the basis of which they are predicted to pose similar biosecurity risks and to require similar risk management measures. In this assessment, the term 'fruit flies' is used to refer to all three species. The scientific name is used when the information relates to specific species.

Bactrocera carambolae, *B. dorsalis* and *B. zonata* are reported to be present in India (Balikai, Kotikal & Prasanna 2009; EPPO 2019; Kapoor 2002; Stibick 2004) and not present in Australia; therefore, they are pests of biosecurity concern for all of Australia.

Bactrocera carambolae is reported to be present only in the Indian islands of Andaman and Nicobar and not in mainland India where pomegranate is produced for export (CABI 2020; Kapoor 2002). As there are no biosecurity controls reported between mainland India and these islands, there is a possibility that this fruit fly could also be present in mainland India, therefore this pest has been included in this risk assessment.

There have been reported detections of fruit fly pests that are of biosecurity concern to Australia in processed arils imported from India and Peru into the USA. These incidents indicate that arils can provide a pathway for fruit flies.

The pest categorisation presented in Appendix A-1 and Appendix A-2 identifies that the three species of fruit flies are associated with both pomegranate whole fruit and processed arils from India. Therefore, the biosecurity risks are separately assessed for the pomegranate whole fruit and processed arils pathways.

Bactrocera dorsalis and *B. zonata* are dominant fruit fly pests of mangoes in India (Clarke et al. 2005; Kapoor 2005) and are also associated with pomegranate in India (FAO & IAEA 2000; ICAR 2017). *Bactrocera carambolae* is a serious pest of carambola, also feeding on over 100 other host species including pomegranate, guava, lemon, orange and mango (EPPO 2019; Marchioro 2016). There is no record of any fruit fly pest species being successfully eradicated in India, nor are there any areas declared free of fruit flies (Kapoor 2002).

Fruit flies have four life stages: egg, larva, pupa and adult (Christenson & Foote 1960). Eggs are laid beneath the skin of host fruit (Cantrell, Chadwick & Cahill 2002; EPPO 2015a) and larvae feed within the fruit before exiting to pupate in the soil under the host plant (Christenson & Foote 1960). Fruit flies can produce several generations each year depending on the temperature, and can be active all year round when conditions are favourable (CABI 2020).

The risk scenario of biosecurity concern for these fruit fly pests is the potential presence of eggs and larvae inside pomegranate whole fruit and/or processed arils from India.

All three fruit fly species have been previously assessed in a number of existing import policies; for example, in the import risk analyses for mangosteen fruit from Thailand (DAFF 2004b) and Indonesia (DAFF 2012), mango fruit from Taiwan (Biosecurity Australia 2006), India

(Biosecurity Australia 2008), Pakistan (Biosecurity Australia 2011b), and Indonesia, Thailand and Vietnam (Department of Agriculture and Water Resources 2015), lychee from Taiwan and Vietnam (DAFF 2013), longan and lychee from China and Thailand (DAFF 2004a), table grapes from China (Biosecurity Australia 2011a) and India (Australian Government Department of Agriculture and Water Resources 2016) and fresh dates from the Middle East and North Africa region (Department of Agriculture and Water Resources 2019b). In these existing policies, the unrestricted risk estimate for fruit flies was uniformly assessed as not achieving the ALOP for Australia, such that specific management measures are required for these pests.

Differences in commodity, horticultural practices and the prevalence of these three species of *Bactrocera* between the export areas considered in the existing policies make it necessary to reassess the likelihood that these fruit flies will be imported into Australia with pomegranate whole fruit and processed arils from India.

Pomegranate whole fruit and processed arils from India is expected to be distributed in Australia in a similar way to commodities assessed previously for fruit flies, for which import policies have been developed to manage the associated risk.

The likelihoods of establishment and spread of fruit flies in Australia for pomegranate whole fruit and processed arils are similar to those of previous assessments. Those likelihoods relate specifically to events that occur in Australia and are essentially independent of the import pathway. The consequences of entry, establishment and spread of these fruit flies with pomegranate whole fruit and processed arils are also independent of the import pathway, and are similar to those of previous pest risk assessments. Therefore, the ratings from the existing policies for the likelihood of distribution, establishment and spread, and the rating for the overall consequences for these fruit fly species have been adopted for the pomegranate whole fruit and processed arils from India pathways.

The department has also reviewed the latest literature (Hill et al. 2016; Kim & Kim 2018; Marchioro 2016; PHA 2018; Satyagopal et al. 2014) and found no new information that would significantly change the risk ratings for distribution, establishment, spread or consequences as set out for fruit flies in the existing policies.

4.1.1 Likelihood of entry with pomegranate whole fruit

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

Likelihood of importation for pomegranate whole fruit

The likelihood that these fruit flies will arrive in Australia with the importation of pomegranate whole fruit from India is assessed as: **High.**

The following information provides supporting evidence for this assessment.

- *Bactrocera carambolae*, *B. dorsalis* and *B. zonata* are present in India and have been reported to infest pomegranate whole fruit (Allwood et al. 1999; Balikai, Kotikal & Prasanna 2009; EPPO 2019; Kapoor 2002).
- *Bactrocera carambolae* is reported to be present only in the Andaman and Nicobar islands, but not in mainland India (CABI 2020; Kapoor 2002) where pomegranates are sourced for

export. However, there are no known biosecurity controls to regulate the movement of risk material from the islands to mainland India.

- Tephritid fruit flies generally lay their eggs directly into host fruit, where the larvae then hatch and grow. While feeding of larvae eventually leads to obvious damage to the fruit, signs of infestation are not obvious when the eggs are laid and larval stages are developing inside the fruit (White & Elson-Harris 1992). Therefore, fruit fly eggs and larvae could avoid commercial packing house practices.
- Pomegranate whole fruit from India are proposed to be stored and transported at a temperature range of 5°C to 8°C. At low temperatures, development times for fruit flies are extended significantly and mortality increases for all life stages (Duyck, Sterlin & Quilici 2004). However, eggs and larvae of *B. carambolae*, *B. dorsalis* and *B. zonata* are known to survive low temperatures for extended periods (Myers et al. 2016), and therefore could survive proposed storage and transport temperatures.

B. carambolae, *B. dorsalis* and *B. zonata* are present in India and reported to infest pomegranate fruit (Allwood et al. 1999; Balikai, Kotikal & Prasanna 2009; EPPO 2019). The difficulty of detecting eggs and larvae inside the fruit during packing house practices, and their ability to survive storage and transport temperatures, all support a likelihood estimate for importation of 'High'.

Likelihood of distribution with pomegranate whole fruit

The likelihood that *B. carambolae*, *B. dorsalis* and *B. zonata* will be distributed within Australia in a viable state as a result of the distribution of pomegranate whole fruit from India for sale, and subsequently transferred to susceptible hosts, is similar to that assessed in the pest risk assessments for *Bactrocera dorsalis* on lychee from Taiwan and Vietnam (DAFF 2013) and longan and lychee from China and Thailand (DAFF 2004a), and for *Bactrocera carambolae* and *B. zonata* assessments on mangoes from Indonesia, Thailand and Vietnam (Department of Agriculture and Water Resources 2015). Therefore, the likelihood of distribution for fruit flies from the pomegranate from India pathway is also assessed as: **High.**

Overall likelihood of entry with pomegranate whole fruit

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

The likelihood that fruit flies will enter in Australia with the importation of pomegranate whole fruit from India is assessed as: **High.**

4.1.2 Likelihood of entry with pomegranate processed arils

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

Likelihood of importation with pomegranate processed arils

The likelihood that these fruit flies will arrive in Australia with the importation of pomegranate processed arils from India is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- Tephritid fruit flies lay their eggs directly into host fruit, where the larvae then hatch and grow. The egg length of *B. zonata* is about 1.0mm to 1.2mm, while the first and second instar larval lengths are about 1.7mm to 2.3mm and 4.0mm to 6.5mm respectively (EPPO 2005). The first, second and third larval instar lengths of *B. dorsalis* are about 1.2mm, 3.2mm and 6.8mm, respectively (Shi et al. 2017).
- Later instars of these species could potentially be detected during aril extraction in packing houses due to their visible sizes. However, eggs and the first instar larvae are likely to go undetected during aril extraction and screening process in packing houses.
- There is a possibility that fruit flies are attracted to fruit waste and extracted arils in packing houses and infest extracted arils. However, the packing house design/construction and processes are likely to minimise the post-extraction infestation of arils with fruit flies. These include fly-proof construction of aril extraction area, separation of pre- and post-extraction activities, segregation of processed arils and fruit, appropriate waste management practices and phytosanitary inspection.
- Pomegranate processed arils from India are proposed to be stored at a temperature range of 0°C to 2°C and transported at a temperature range of 1°C to 5°C. At low temperatures, development times for fruit flies are extended significantly and mortality increases for all life stages (Duyck, Sterlin & Quilici 2004). However, eggs and larvae of *B. carambolae, B. dorsalis* and *B. zonata* could survive proposed storage and transport temperatures (Myers et al. 2016).
- Aril processing and storage processes, including the use of modified atmosphere packaging, if used, with reduced oxygen and increased nitrogen and carbon dioxide concentrations may reduce the survival of fruit flies. Modified atmosphere packaging with reduced oxygen and increased carbon dioxide has been reported to be insecticidal (Neven, Yahia & Hallman 2009).
- There have been incidences where fruit fly larvae have been detected in arils imported from India and Peru into the USA, indicating the potential that arils can provide a pathway for fruit flies.

Bactrocera carambolae, *B. dorsalis* and *B. zonata* are present in India and reported to infest pomegranate fruit. The packing house design and processes, including segregation of processed arils from unprocessed fruit, appropriate waste management practices, modified atmosphere packaging, if used, and the likelihood that later instar larvae may be detected during packing house processes minimise the risk of fruit fly infestation. However, the difficulty of detecting eggs and early instars during aril extraction in packing houses, their ability to survive storage and transport temperatures, and the detection of fruit fly larvae in imported arils in the USA support a likelihood estimate for importation of 'Moderate'.

Likelihood of distribution with pomegranate processed arils

Similar to pomegranate whole fruit, the likelihood that *B. carambolae*, *B. dorsalis* and *B. zonata* will be distributed within Australia in a viable state as a result of the distribution of pomegranate processed arils from India for sale, and subsequently transferred to susceptible hosts, is similar to that assessed in the pest risk assessments for *Bactrocera dorsalis* on lychee from Taiwan and Vietnam (DAFF 2013) and longan and lychee from China and Thailand (DAFF

2004a), and for *Bactrocera carambolae* and *B. zonata* assessments on mangoes from Indonesia, Thailand and Vietnam (Department of Agriculture and Water Resources 2015).

Eggs and early instar larvae that could be present in imported pomegranate processed arils are likely to survive the proposed transport and storage temperatures (1°C to 5°C), as this temperature range is not lethal over shorter periods of time. On exposure of arils to ambient temperatures during retail outlet displays and household usage, immature stages of fruit flies are likely to develop, complete the life cycle and potentially find a host.

Therefore, the likelihood of distribution of fruit flies from the pomegranate processed arils from India pathway is also assessed as: **High.**

Overall likelihood of entry with pomegranate processed arils

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

The likelihood that fruit flies will arrive in Australia with the importation of pomegranate processed arils from India is assessed as: **Moderate.**

4.1.3 Likelihood of establishment and spread with pomegranate whole fruit and processed arils

The likelihoods of establishment and spread of *B. carambolae*, *B. dorsalis* and *B. zonata* are similar for pomegranate whole fruit and processed arils. Therefore, the assessment below is applied for both pomegranate whole fruit and processed arils.

The likelihoods of establishment and spread for fruit flies are similar to those assessed in the pest risk analysis for *B. carambolae*, *B. dorsalis* and *B. zonata* on mangoes from Taiwan (Biosecurity Australia 2006), Indonesia, Thailand and Vietnam (Department of Agriculture and Water Resources 2015), longan and lychee from China and Thailand (DAFF 2004a) and lychee from Taiwan and Vietnam (DAFF 2013). The ratings from previous assessments are:

Likelihood of establishment: **High**

Likelihood of spread: **High**

4.1.4 Overall likelihood of entry, establishment and spread for pomegranate whole fruit and processed arils

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

The overall likelihood that the fruit flies will enter Australia as a result of trade in pomegranate whole fruit from India, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is assessed as: **High.**

The overall likelihood that the fruit flies will enter Australia as a result of trade in pomegranate processed arils from India, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is assessed as: **Moderate.**

4.1.5 Consequences of fruit flies in pomegranate whole fruit and/or processed arils

The consequences of *B. carambolae*, *B. dorsalis* and *B. zonata* entering, establishing and spreading in Australia are similar for pomegranate whole fruit and processed arils. Therefore, the assessment for consequences below is applied for both pomegranate whole fruit and processed arils.

The potential consequences of the establishment of fruit flies in Australia are similar to those assessed in the pest risk analyses for *B. carambolae*, *B. dorsalis* and *B. zonata* for mango fruit from Taiwan (Biosecurity Australia 2006), Indonesia, Thailand and Vietnam (Department of Agriculture and Water Resources 2015). The overall consequences in the previous assessments were assessed as 'High'. Therefore, the overall consequences for *B. carambolae*, *B. dorsalis* and *B. zonata* on the pomegranate whole fruit and/or processed arils from India pathways are also assessed as: **High**.

4.1.6 Unrestricted risk estimate for fruit flies on pomegranate whole fruit

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

Unrestricted risk estimate for *Bactrocera carambolae*, *B. dorsalis* and *B. zonata* on pomegranate whole fruit	
Overall likelihood of entry, establishment and spread	High
Consequences	High
Unrestricted risk	High

The unrestricted risk estimates for fruit flies on the pomegranate whole fruit from India pathway have been assessed as 'High', which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *B. carambolae*, *B. dorsalis* and *B. zonata* on this pathway.

4.1.7 Unrestricted risk estimate for fruit flies on pomegranate processed arils

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

Unrestricted risk estimate for *Bactrocera carambolae*, *B. dorsalis* and *B. zonata* on pomegranate processed arils	
Overall likelihood of entry, establishment and spread	Moderate
Consequences	High
Unrestricted risk	High

The unrestricted risk estimates for fruit flies on the pomegranate processed arils from India pathway have been assessed as 'High' which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *B. carambolae*, *B. dorsalis* and *B. zonata* on this pathway.

4.2 Cornelian butterfly and Pomegranate butterfly

Deudorix epijarbas (EP, WA) and *Deudorix isocrates*

Deudorix epijarbas (cornelian butterfly) and *Deudorix isocrates* (pomegranate butterfly) belong to the family Lycaenidae. These fruit borers have been grouped together as they are closely related, with similar biologies and behaviours, such that they are predicted to pose similar biosecurity risks and to require similar risk management measures. In this assessment, the term '*Deudorix*' is used to refer to these two species. Scientific names are used when the information refers to an individual species.

Deudorix epijarbas is known to occur in Bangladesh, China, India, Indonesia, Philippines, Taiwan Thailand and eastern Australia (Herbison-Evans & Crossley 2019; Kalshoven 1981; Shihan 2015). *Deudorix isocrates* is known to occur in Afghanistan, Bhutan, India, Nepal, Pakistan and Sri Lanka (Ramana et al. 2016).

Deudorix isocrates is not present in Australia and is therefore a pest of biosecurity concern for all of Australia. *Deudorix epijarbas* is not present in the state of Western Australia and is a pest of biosecurity concern for that state.

The Lycaenidae is a large and diverse family, containing 4,500 species of butterflies (Fiedler 1996). Species from the Lycaenidae family commonly feed on plants of the legume family and on a wide variety of fruits (Avidov & Harpaz 1969b).

Deudorix are polyphagous (Balikai, Kotikal & Prasanna 2009), with host species widely distributed in Australia. Although many hosts have been identified, significant damage has only been reported on pomegranate, citrus and guava (Bagle 2011; Chhetry, Gupta & Tara 2015; Gupta & Dubey 2005; Rama Devi & Jha 2017).

Deudorix have four life stages: egg, larva, pupa and adult. Eggs are laid on host fruits, flowers, stems and leaves (Kumar 2014; Mohi-ud-din et al. 2018b; Ramana et al. 2016). Mated females are capable of laying up to 25 to 32 eggs in their lifetime (Khandare, Kadam & Jayewar 2018; Mohi-ud-din 2014; Mohi-Ud-Din et al. 2018a; Ramana et al. 2016; Zaka-Ur-Rab 1980). After hatching, larvae bore into fruit to feed on the pulp and seeds (Kumar et al. 2017; Thakur et al. 1995). Feeding continues until larvae are ready to pupate. At this point, the larvae exit the fruit and secure the fruit to the tree with fine threads before re-entering (Paul 2007; Verma 1985), or finding an alternative place to pupate, including outside the fruit, on leaves or in soil (Kumar 2014; Mohi-ud-din 2014; Mohi-Ud-Din et al. 2018a; Verma 1985). Adults are capable of independent movement and can fly to find a suitable mate and host.

The pest categorisation presented in Appendix A-1 and Appendix A-2 identifies *D. epijarbas* and *D. isocrates* as associated with both pomegranate whole fruit and processed arils from India. Therefore, the biosecurity risks are separately assessed for the pomegranate whole fruit and processed arils pathways. While the pathway associations of *Deudorix* and the likelihoods of entry differ between the pomegranate whole fruit and processed arils pathways, the likelihoods of establishment and spread in Australia with pomegranate whole fruit and processed arils are similar. Those likelihoods relate specifically to events that occur in Australia and are essentially independent of the route of entry. The consequences of entry, establishment and spread for *Deudorix* with pomegranate whole fruit and processed arils are also independent of the import pathway. Therefore, the likelihoods of entry are assessed separately for pomegranate whole fruit and processed arils, and likelihoods of establishment, spread and consequences are assessed as covering both pomegranate whole fruit and processed arils pathways.

The risk scenario of biosecurity concern for *Deudorix* is the potential presence of eggs, larvae and/or pupae on or in pomegranate whole fruit from India, and early instar larvae in processed arils. Adults are unlikely to be present on the pathways of pomegranate whole fruit or processed arils as they are likely to be detected during packing house processes.

Deudorix epijarbas has been previously assessed for the longan and lychee fruit pathways from the People's Republic of China and Thailand (DAFF 2004a). *Deudorix epijarbas* will be assessed here, along with *D. isocrates*, due to pathway differences including commodity type, horticultural practices, differing prevalence of pest species between export areas, and host ranges of these pests. The risk assessment presented here builds on the previous assessment of *D. epijarbas* on longan and lychee fruit from the People's Republic of China and Thailand (DAFF 2004a).

The department has reviewed the latest literature on *Deudorix* (Kumar et al. 2017; Mallikarjun & Pal 2018; Mohi-ud-din 2014; Paul 2007; Ramana et al. 2016; Sharma & Batra 2007; Sunita 2012; Yousuf, Ikram & Faisal 2015). New information includes reports of infestation rates of up to eight *Deudorix* larvae in a single pomegranate fruit (Mohi-ud-din 2014), in comparison with previous reports of a single egg laid on longan or lychee fruit, and consequently infested fruit containing only a single larva (Waite & Hwang 2002).

4.2.1 Likelihood of entry with pomegranate whole fruit

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

Likelihood of importation

The likelihood that *Deudorix* will arrive in Australia with the importation of pomegranate whole fruit from India is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- *Deudorix epijarbas* and *D. isocrates* are present on pomegranate in India (Balikai, Kotikal & Prasanna 2009). *Deudorix epijarbas* is considered a serious pest of pomegranate in Himachal Pradesh and Jammu and Kashmir (Sharma & Batra 2007); and *D. isocrates* occurs in all major Indian states of pomegranate production (Paul 2007).
- Adult *Deudorix* females lay eggs on pomegranate plants, including on the fruit, preferentially on the fruit calyx (Kaith 2001; Khan et al. 2017; Mohi-ud-din 2014; Ramana et al. 2016). Eggs are greenish-white, with *D. isocrates* eggs developing a bright blue tinge and averaging 0.51mm to 1.01mm in diameter (Bhut 2012; Mohi-ud-din 2014). Egg incubation periods average six to 11 days (Chhetry, Gupta & Tara 2015; Kaith 2001).
- *Deudorix* larvae infest pomegranate fruit, boring and feeding internally on the mesocarp and seeds (Kumar et al. 2017; Thakur et al. 1995). The larval period consists of five instars and averages 12 to 45 days (Balikai, Kotikal & Prasanna 2009; Kaith 2001; Khandare, Kadam & Jayewar 2018). A single fruit may be infested by up to eight *Deudorix* larvae (Balikai, Kotikal & Prasanna 2009; Mohi-ud-din 2014). Multiple entry holes in a single fruit would increase the likelihood of detection during visual inspection prior to fruit export.

- Larval entry holes in pomegranate fruit increase in size depending on the development stage of the larvae (Mohi-Ud-Din et al. 2018a). First instar larvae are of 0.88mm to 0.90mm diameter on average (Mallikarjun & Pal 2018; Mohi-ud-din 2014) and entry holes created at this larval stage may go undetected. However, entry holes created by the fifth instar larval stage would be easily detected, with the diameter of larvae averaging 5.97mm to 6.00mm (Mallikarjun & Pal 2018; Mohi-ud-din 2014).
- Other external symptoms of larval attack are also likely to be detected prior to pomegranate whole fruit export. These include larval entry holes having excreta collected at the fruit surface, an offensive odour, and the posterior end of the larva plugging the entry hole (Balikai, Kotikal & Prasanna 2009; Kumar 2014; Mohi-ud-din 2014). Ants are often seen foraging at entry holes, attracted by a sugary substance produced by the larvae (Kumar 2014; Waite & Hwang 2002). Infested fruit also becomes susceptible to fungal and bacterial infection, leading to visible fruit rot (Mallikarjun & Pal 2018; Mohi-ud-din 2014; Sunita 2012).
- Some infested pomegranate fruit will not reach harvest, as fruit infested by *Deudorix* larvae eventually rot, desiccate and drop prematurely from the tree (Kumar & Gupta 2018; Reddy 2014).
- *Deudorix* can pupate on the surface and/or inside of pomegranate fruit (Kaith 2001; Paul 2007). The pupal period is 7 to 13 days for *D. epijarbas* (Kaith 2001; Mohi-Ud-Din et al. 2018a) and five to 30 days for *D. isocrates* (Gundappa, Muralidhara & Rajan 2017; Ramana et al. 2016).
- Pupae occurring on the outside of the fruit are distinctive and likely to be detected visually. *Deudorix epijarbas* pupae are whitish-brown and average 11.37mm to 14.95mm in length and 3.81mm to 6.13mm in width (Kaith 2001; Mohi-ud-din 2014); *D. isocrates* pupae are brown and average 13.0mm to 14.25mm in length and 6.25mm to 6.59mm in width (Kumar et al. 2017; Mallikarjun & Pal 2018). Prior to pupation within pomegranate fruit, larvae secure the fruit to the tree via fine threads (Paul 2007; Verma 1985). The threads, and the entry hole used for pupation in the fruit are likely to be detected during harvest and packing house processes.
- *Deudorix isocrates* has been reported to overwinter as pupae (Ramana et al. 2016); therefore, pupae are likely to survive storage and transport of pomegranate whole fruit at the proposed transport temperature of 5°C to 8°C. *Deudorix epijarbas* was reported as a serious pest in the Indian state of Jammu and Kashmir (Sharma & Batra 2007), where the temperature drops to well below 5°C to 8°C, suggesting that *Deudorix* larvae may survive storage and transport.
- Standard packing house procedures including washing pomegranate whole fruit is likely to remove *Deudorix* eggs. However, *Deudorix* have been reported to lay eggs inside the pomegranate fruit calyx, which is often folded over, and from where cleaning and visual inspection may fail to remove them. This, together with their small size, may result in eggs in the calyx being undetected.

Deudorix are present in India and reported on pomegranate fruit. *Deudorix* have a preference for egg-laying on the fruit calyx and larvae bore into and pupate internally in the fruit. It is possible that *Deudorix* eggs, larvae and pupae may survive storage and transport. Infested fruit may drop prematurely from the tree, and external symptoms of infestation are visually distinctive, and standard packing house procedures including washing pomegranate whole fruit are likely to remove *Deudorix* eggs and pupae from the fruit surface. However, it is possible that early instar larvae inside the fruit may go undetected because smaller entry holes of first instars are likely to be more difficult to detect. These factors support a likelihood estimate for importation of 'Moderate'.

Likelihood of distribution with pomegranate whole fruit

The likelihood that *Deudorix* will be distributed within Australia in a viable state as a result of processing, sale or disposal of pomegranate whole fruit from India, and subsequently transfer to a susceptible part of a host is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- Pomegranate whole fruit would be distributed for sale to various destinations in Australia. They may be distributed through large fresh produce wholesale markets and then to supermarkets or other sellers, or directly to smaller retailers and then to consumers.
- *Deudorix isocrates* has been reported to overwinter as pupae (Ramana et al. 2016); therefore, pupae are likely to survive storage and transport of pomegranate whole fruit at the proposed temperature of 5°C to 8°C.
- External symptoms of infestation such as entry holes, larval excreta, offensive odour and secondary fruit rot are likely to be detected. Infested fruit with obvious symptoms are therefore likely to be discarded prior to reaching the market.
- Pomegranates have a thick leathery rind and arils need to be extracted for consumption. Therefore, infested pomegranate waste is likely to be disposed of as municipal waste, from where it is unlikely to distribute *Deudorix* into the environment. However, pomegranate waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetation.
- It is possible for *Deudorix* to complete their life cycle within pomegranate whole fruit; larvae enter pomegranate fruit to feed (Kumar et al. 2017; Thakur et al. 1995) and pupation can occur within pomegranate fruit (Kaith 2001; Paul 2007). It is therefore possible that adult *Deudorix* may emerge from discarded pomegranate fruit.
- However, the condition of discarded pomegranate is expected to deteriorate quickly in the environment and may prevent larvae from progressing to the pupal stage. Larvae feed until maturity (Mohi-ud-din 2014; Ramana et al. 2016) and the larval period averages 12 to 45 days (Balikai, Kotikal & Prasanna 2009; Kaith 2001). Fruit damaged by *Deudorix* are reported to be susceptible to fungal and bacterial attack, leading to fruit rot (Mallikarjun & Pal 2018; Mohi-ud-din 2014; Sunita 2012). It is also expected that discarded pomegranate fruit will lose moisture rapidly.
- *Deudorix* is polyphagous with a wide range of hosts including apple, citrus, guava, mulberry, peach, pear, plum, jujube and pomegranate (Balikai, Kotikal & Prasanna 2009). Many of these plants are widely grown in Australia and could provide a suitable host for the pest upon importation into Australia.
- Adults of *Deudorix* are capable of flying to find a mate and suitable host. The *Deudorix* genus is classified in the Theclinae sub-family, of which most members are fast flyers (Akand et al.

2017). *Deudorix isocrates* is described as an efficient flier, using rapid wing beats (Ramana et al. 2016).

Pomegranate whole fruit will be distributed across Australia, and it is possible *Deudorix* eggs, larvae and pupae in infested fruit may survive storage and transport. Infested fruit may be disposed of as litter in the environment, where it is possible that *Deudorix* will be able to complete their lifecycles, and emerging adults could find a suitable host as many of its reported hosts are widely grown in Australia. However, the majority of pomegranate waste will be disposed of via municipal waste systems where the immature stages of the pest are less likely to develop into adults. These factors support a likelihood estimate for importation of 'Moderate'.

Overall likelihood of entry with pomegranate whole fruit

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

The likelihood that *Deudorix* will enter Australia as a result of trade in pomegranate whole fruit from India, and be distributed in a viable state to a susceptible host, is assessed as: **Low**.

4.2.2 Likelihood of entry with pomegranate processed arils

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

Likelihood of importation

The likelihood that *Deudorix* will arrive in Australia with the importation of pomegranate processed arils from India is assessed as: **Low**.

The following information provides supporting evidence for this assessment.

- *Deudorix* larvae, on hatching, bore into the fruit and feed internally on the mesocarp and seeds (Kumar et al. 2017; Thakur et al. 1995).
- Larval size increases during development and later instars are likely to be detected when arils are extracted from fruit in packing houses. However, early instars may not be detected as they are small, with first instars of *D. epijarbas* measuring about 1.5mm x 0.9mm and those of *D. isocrates* about 2.5mm x 0.9mm in length and width, respectively (Chhetry, Gupta & Tara 2015; Mohi-ud-din 2014).
- A single fruit may contain up to eight *Deudorix* larvae, increasing the likelihood of *Deudorix* larvae being present in arils extracted from fruit at an early stage of infestation (Balikai, Kotikal & Prasanna 2009; Mohi-ud-din 2014).
- Fruit at an early stage of infestation may escape detection and could be used for aril extraction. Larval entry holes in pomegranate fruit increase in size with the developmental stage of the larvae (Mohi-Ud-Din et al. 2018a). However, first instar larvae are of about 0.9mm in width on average (Mallikarjun & Pal 2018; Mohi-ud-din 2014), and entry holes created on the fruit by first instar larvae may go undetected during visual inspection prior to use. However, entry holes created by later instar larval stages may be more readily detected, with fifth larval instars averaging about 6.0mm in width (Mallikarjun & Pal 2018; Mohi-ud-din 2014).

- It is possible that *Deudorix* butterflies are attracted to fruit waste and extracted arils in packing houses and infest extracted arils. However, the packing house design/construction and processes including fly proof construction of aril extraction area, separation of pre-and post-extraction activities and segregation of processed and unprocessed arils, and appropriate waste management practices are likely to minimise the post extraction infestation of arils with *Deudorix* flies.
- *Deudorix* can pupate in pomegranate fruit (Kaith 2001; Paul 2007); however, pupae are likely to be detected in arils during packing house practices due to the size and colour of pupae. *Deudorix epijarbas* pupae are whitish-brown, averaging about 11mm to 15mm in length and about 4mm to 6mm in width (Kaith 2001; Mohi-ud-din 2014); *D. isocrates* pupae are brown and about 13mm to 14mm long and about 6mm wide (Kumar et al. 2017; Mallikarjun & Pal 2018).
- Other external symptoms of larval attack are also likely to be detected prior to fruit being used for extraction of arils for export. Larval entry holes are associated with excreta collected at the fruit surface, an offensive odour, and the posterior end of the larva is sometimes visible plugging the entry hole (Balikai, Kotikal & Prasanna 2009; Kumar 2014; Mohi-ud-din 2014).
- Infested fruit also becomes susceptible to fungal and bacterial infection, leading to visible fruit rot (Mallikarjun & Pal 2018; Mohi-ud-din 2014; Sunita 2012), and is likely to be detected and discarded from being used for aril extraction.
- Aril processing and storage processes, including the use of modified atmosphere packaging, if used, with reduced oxygen and increased nitrogen and carbon dioxide concentrations may reduce the survival of *Deudorix*. Modified atmosphere packaging with reduced oxygen and increased carbon dioxide has been reported to be insecticidal (Yahia & Singh 2009). The lower storage and transport temperature (below 5°C) is also likely to reduce the survival of *Deudorix* on processed arils. In addition, there are no reports of *Deudorix* being intercepted in fresh processed arils, suggesting it is less likely to be on this pathway.

Deudorix are present in India and reported on pomegranate fruit. The packing house processes are likely to detect fruit infested by older larval instars due to the size of the holes they create. The possibility of early instars being present in arils extracted from fruit at an early stage of infestation is moderated by the fact that modified atmosphere packaging, if used, and low storage and transport temperatures are likely to reduce the survival of the pest. This is supported by no reports of *Deudorix* being detected in fresh processed arils. These factors support a likelihood estimate for importation of 'Low'.

Likelihood of distribution with pomegranate processed arils

The likelihood that *Deudorix* will be distributed within Australia in a viable state as a result of sale or disposal of pomegranate processed arils from India, and subsequently transfer to a susceptible part of a host is assessed as: **Very Low**.

The following information provides supporting evidence for this assessment.

- Pomegranate processed arils would be distributed for sale to various destinations in Australia, although predominantly to the larger population centres. They may be distributed through large fresh produce wholesale markets and then to supermarkets or other sellers, or directly to smaller retailers and then to consumers.

- Processed arils will be distributed in modified atmosphere packaging filled with nitrogen and carbon dioxide gas, held at lower storage and transport temperatures (below 5°C), which are likely to reduce the survival of *Deudorix*.
- Unlike pomegranate whole fruit, 'ready-to-eat' arils are already processed and have no perishable waste such as mesocarp and rind that could harbour these pests and assist distribution to suitable hosts.
- However, *Deudorix* is polyphagous with a reported wide range of hosts, including apple, citrus, guava, mulberry, peach, pear, plum, jujube and pomegranate (Balikai, Kotikal & Prasanna 2009). Many of these plants are widely grown in Australia and could provide a suitable host should *Deudorix* survive processes such as storage and transportation.
- *Deudorix* larvae have been reported to enter (Kumar et al. 2017; Thakur et al. 1995) and pupate within pomegranate fruit (Kaith 2001; Paul 2007). It is therefore possible that any larvae in pomegranate arils that survive while in modified atmosphere packaging could possibly develop into the pupal stage and be disposed as waste. However, this is only likely when the package has been opened and environmental conditions are favourable for such development.
- *Deudorix* have been reported to pupate in places other than pomegranate, including in the soil (Kumar 2014; Mohi-ud-din 2014; Mohi-Ud-Din et al. 2018a; Verma 1985). However, any infested and/or expired arils are likely to be disposed of as municipal waste and are unlikely to provide suitable habitat to complete a life cycle.
- Arils that are discarded in the environment are unlikely to support complete *Deudorix* development, because their condition will deteriorate quickly in the environment. Larvae are reported to feed until maturity (Mohi-ud-din 2014; Ramana et al. 2016) and the larval period averages 12 to 45 days (Balikai, Kotikal & Prasanna 2009; Kaith 2001). The shorter 21-day shelf-life of processed arils is likely to limit potential as a host for the completion of larval development.
- However, should adults emerge from infested arils, it is likely that they could find a host and mate as adults of *Deudorix* are capable of flying. The *Deudorix* genus is classified in the Theclinae sub-family, of which most members are fast flyers (Akand et al. 2017). *Deudorix isocrates* is described as an efficient flier, using rapid wing beats (Ramana et al. 2016).

Processed pomegranate arils will be distributed across Australia and could potentially contain early instar *Deudorix* larvae. However, the survival of the pest is less likely due to the use of modified atmosphere packaging with reduced oxygen concentration and the low temperatures used for storage and transport. Larvae in infested arils discarded in the environment are unlikely to be able to complete their lifecycles as arils will deteriorate quickly and are unlikely to support full larval development. Most pomegranate aril waste is likely to be disposed of via municipal waste systems. These factors support a likelihood estimate for distribution of ' Very Low'.

Overall likelihood of entry with pomegranate processed arils

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

The likelihood that *Deudorix* will enter Australia as a result of trade in pomegranate processed arils from India, and be distributed in a viable state to a susceptible host, is assessed as: **Very Low.**

4.2.3 Likelihood of establishment with pomegranate whole fruit and processed arils

The likelihood of establishment of *Deudorix* is similar for pomegranate whole fruit and processed arils. Therefore, the assessment below is applied for both pomegranate whole fruit and processed arils.

The likelihood that *Deudorix* will establish in Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as: **High**.

The following information provides supporting evidence for this assessment.

- *Deudorix* has a suitable reproductive strategy to establish in Australia. Sexual reproduction requires emerging adults to find a mate in order to reproduce. *Deudorix epijarbas* males live for five to 10 days and females live for four to 13 days (Kaith 2001; Mohi-ud-din 2014). *Deudorix isocrates* males live for three to 12 days and females live for four to 18 days (Chhetry, Gupta & Tara 2015; Ramana et al. 2016).
- *Deudorix isocrates* adults have been reported to communicate via female sex pheromones (Wahab 2009).
- Due to infestation rates of up to eight *Deudorix* larvae in a single pomegranate fruit (Balikai, Kotikal & Prasanna 2009; Mohi-ud-din 2014), it is possible that a suitable mate may emerge from the same fruit.
- *Deudorix* are polyphagous (Balikai, Kotikal & Prasanna 2009), with many host species present in Australia and widely distributed. This increases the likelihood of the species finding a suitable host.
- *Deudorix epijarbas* has been reported to be strongly associated with pomegranate (Gupta & Dubey 2005). Other hosts of *Deudorix* are considered to be minor, as no significant damage has been reported. These hosts include commercial plants such as longan, lychee, macadamia and rambutan, and non-commercial plants such as horse chestnut (*Aesculus hippocastanum*) and Chinese Salacia (*Salacia chinensis*)(Braby 1997; Hill 2008; Loc, Kumar & Chakravarthy 2018; Waite & Hwang 2002; Zaka-Ur-Rab 1980).
- *Deudorix isocrates* has been reported to be strongly associated with pomegranate, citrus and guava (Bagle 2011; Chhetry, Gupta & Tara 2015; Rama Devi & Jha 2017). Other commercial hosts include apple, loquat, lychee, mulberry, peach, pear, plum, sapota and tamarind, and non-commercial plants such as chinee apple (*Ziziphus mauritiana*) may also be utilised (Balikai, Kotikal & Prasanna 2009; Chhetry, Gupta & Tara 2015; Gundappa, Muralidhara & Rajan 2017; Khan et al. 2017; Paul 2007).
- The relatively high fecundity of *Deudorix* increases the likelihood of establishment. Females are capable of laying up to 25–32 eggs in their lifetime (Kumar 2014; Mohi-ud-din 2014).

Deudorix have been reported to complete four overlapping generations per year on pomegranate (Paul 2007; Verma 1985).

- Suitable environmental conditions are available in Australia for *Deudorix* species to establish. The species occur across southern Asia (Herbison-Evans & Crossley 2018; Kalshoven 1981; Ramana et al. 2016; Shihan 2015) and are reported to be widely distributed in India. According to Köppen climate maps, corresponding climate regions occur across Australia (Peel, Finlayson & McMahon 2007).
- *Deudorix* populations have been found to decline following release of *Trichogramma* parasitoids (Sharma & Batra 2007). In India, under natural conditions, various parasitoids were reported to attack up to 62% of *D. epijarbas* eggs, up to 15% of *D. epijarbas* larvae and up to 60% of *D. isocrates* eggs (Sharma & Batra 2007). Parasitoids which attack *D. epijarbas* include *Trichogramma chilonis* and *Telenomus cyrus* (Thakur et al. 1995). Parasitoids that attack *D. isocrates* include *Trichogramma manii*, *T. chilotraeae*, *Telenormus* species and *Ooencyrtus papilionis* (Sharma & Batra 2007; Yousuf, Ikram & Faisal 2015). Species belonging to these genera are present in Australia; however, it is unknown whether they would have an impact on *Deudorix* population numbers.
- *Deudorix epijarbas* is already established in tropical and sub-tropical parts of eastern Australia (Braby 2016); however, this species is not present in the state of Western Australia and is a pest of biosecurity concern for that state.

Deudorix species have suitable reproductive strategies, including high fecundities and mate-finding mechanisms, and a range of hosts that are widely distributed across Australia. Climatic conditions in Australia are expected to favour their establishment, as *D. epijarbas* has already established in eastern Australia. There is no reported evidence about natural control mechanisms (e.g. natural enemies) for these pests in Australia. These factors support a likelihood estimate for establishment of 'High'.

4.2.4 Likelihood of spread with pomegranate whole fruit and processed arils

The likelihood of spread of *Deudorix* is similar for pomegranate whole fruit and processed arils. Therefore, the assessment below is applied for both pomegranate whole fruit and processed arils.

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

The following information provides supporting evidence for this assessment.

- Suitable climatic regions are available across Australia, and adult *Deudorix* are capable of independent flight. The *Deudorix* genus is classified in the Theclinae sub-family, of which most members are fast flyers (Akand et al. 2017) and *Deudorix isocrates* is described as an efficient flier, using rapid wing beats (Ramana et al. 2016). It is likely that *Deudorix* would spread naturally where suitable hosts are available.
- Many host species present in Australia are commercially grown fruits and nuts, which are likely to be distributed domestically for sale and consumption. It is possible that infested fruits, and associated *Deudorix*, would spread via this pathway.

- The wide-spread occurrence of this pest in other countries, particularly in India—from Southern (Tamil Nadu) and South-western (Maharashtra) parts of the country to the western-Himalayas (Himachal Pradesh)—indicates that the natural barriers may not limit the spread of this pest within Australia.
- Parasitoids that attack *D. isocrates* include *Trichogramma manii*, *T. chilotraeae*, *Telenormus* species and *Ooencyrtus papilionis* (Sharma & Batra 2007; Yousuf, Ikram & Faisal 2015). Although some species belonging to these genera are present in Australia, it is unknown whether they would have an impact on *Deudorix* population numbers.

Deudorix are polyphagous, with multiple hosts widely distributed across Australia, adults are strong fliers and can readily find suitable hosts, and there are no reports on the activities of identified natural enemies in Australia. Australia provides suitable environmental conditions with no evidence for natural barriers preventing the spread of this pest. These factors support a likelihood estimate for spread of 'High'.

4.2.5 Overall likelihood of entry, establishment and spread with pomegranate whole fruit

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

The likelihood that *Deudorix* will enter Australia as a result of trade in pomegranate whole fruit from India, be distributed in a viable state to a susceptible host, establish in Australia, and subsequently spread within Australia is assessed as: **Low**.

4.2.6 Overall likelihood of entry, establishment and spread with pomegranate processed arils

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

The likelihood that *Deudorix* will enter Australia as a result of trade in pomegranate processed arils from India, be distributed in a viable state to a susceptible host, establish in Australia, and subsequently spread within Australia is assessed as: **Very Low.**

4.2.7 Consequences

The consequences of entry, establishment and spread of *Deudorix* are similar for the pomegranate whole fruit and processed arils. Therefore, the assessment below is applied for both pathways.

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

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

Criterion	Estimate and rationale
Direct	
Plant life or health	D – Minor significance at the regional level

	Although many hosts of *D. epijarbas* and *D. isocrates* have been identified, significant impact to plant life or health has only been reported on pomegranate, citrus and guava. *Deudorix epijarbas* is known to occur in eastern Australia (Moulds 1976); however, the pest has not been reported to cause major damage to host plants and production in the region, suggesting that its impact may be likely to be lower in Australia than in India. *Deudorix epijarbas* is considered a pest of pomegranate (Zaka-Ur-Rab 1980), longan and lychee (Waite & Hwang 2002) and *D. isocrates* is considered a pest of pomegranate (Khan et al. 2017), citrus and guava (Gundappa, Muralidhara & Rajan 2017). Larvae bore inside the fruit of these hosts to feed on pulp and seeds (Gundappa, Muralidhara & Rajan 2017; Kumar et al. 2017; Thakur et al. 1995; Waite & Hwang 2002). Infested fruit is then susceptible to secondary attack by fungi and bacteria, leading to fruit rot (Mallikarjun & Pal 2018; Mohi-ud-din 2014; Sunita 2012). In pomegranate orchards in India, infestation rates have been reported to be up to 60% by *D. epijarbas* (Gupta & Dubey 2005) and up to 90% by *D. isocrates* (Bagle 2011). The commercial pomegranate industry is small in Australia; however, it is expected to expand. In 2014, pomegranate production areas totalled about 500 hectares in districts in Queensland, New South Wales, South Australia, Victoria and Western Australia (AgriFutures Australia 2017b). In a citrus (*Citrus sinensis*) grove in the Indian State of Jammu and Kasmir, *D. isocrates* damage of up to 18% was reported during a period of five months when the orchard was maintained free from insecticidal treatment (Chhetry, Gupta & Tara 2015); however, the authors noted that the loss inflicted had not reached economic threshold. In Australia citrus production areas cover over 28,000 hectares, distributed across New South Wales, the Northern Territory, South Australia, Queensland, Victoria and Western Australia (Citrus Australia 2016a). In guava orchards in India, infestation rates have been reported to be up to 26.4% by *D. isocrates* (Rama Devi & Jha 2017). In Australia, guava production areas are limited, consisting of approximately 21 hectares (ABARES 2017), dispersed in Queensland, New South Wales and the Northern Territory (Menzel 1985; Northern Territory Government of Australia 2017).
Other aspects of the environment	A – Indiscernible at the local, district, regional and national levels The impact of *D. epijarbas* and *D. isocrates* on native butterflies through competition for resources locally is unknown. Although *D. epijarbas* and *D. isocrates* are reported to attack other host species, high infestation rates have only been reported on pomegranate and guava (Bagle 2011; Gupta & Dubey 2005; Rama Devi & Jha 2017). They are therefore less likely to cause an impact on native animals or plants. *Deudorix epijarbas* has established in eastern Australia (Braby 2016) and a review of the published literature has found no report of significant impact on other aspects of the environment.
Indirect	
Eradication, control	C- Minor significance at the district level Any eradication action, particularly chemical control in response to an incursion of *D. epijarbas* or *D. isocrates*, would be costly and would cause disruption to agribusiness and associated trades within the affected area. The impact of *Deudorix* would be expected to lead to a minor decrease in agricultural production, but not expected to threaten economic viability of production, noting potential for an increase in costs associated with crop monitoring, consultant advice, containment, eradication and control of these pests on infested crops at the local level. A variety of chemical, biological and physical control agents have been effective in controlling *D. epijarbas* and *D. isocrates* (Arora, Singh & Dhawan 2012; Bagle 2011; Gupta & Dubey 2005; Khan et al. 2017; Kumar & Gupta 2018; Paul 2007; Sharma & Batra 2007; Thakur et al. 1995; Yousuf, Ikram & Faisal 2015). Use of these control agents would have significant associated cost. Chemical and biological control agents are likely to add costs to production. Physical control methods would also take a significant amount of time, which would incur labour costs.
Domestic trade	C – Minor significance at the district level The Australian pomegranate industry is currently focused on the domestic market and small-scale producers sell fruit to retailers or in local markets (AgriFutures Australia

	2017b). The commercial pomegranate industry is small in Australia; however it is expected to expand. The Australian citrus industry caters for the domestic market, with 100,000 tonnes of oranges sold domestically each year (Citrus Australia 2016b). Compliance with domestic biosecurity requirements may impose additional costs for producers, rendering part of existing and/or future interstate trade uneconomical.
International trade	D – Significant at the district level Australia currently has export market access for pomegranate to Fiji, Indonesia, Nauru, Papua New Guinea, Qatar, Singapore Tonga and United Arab Emirates. Australia exports approximately 205,000 tonnes of citrus to over 40 countries including China, Hong Kong, Japan, Singapore and United Arab Emirates (Citrus Australia 2016a). If *Deudorix epijarbas* and *Deudorix isocrates* established in Australia, trading partners may review their phytosanitary requirements for affected commodities, including the possibility of suspending or stopping trade and/or imposing additional measures. Existing market access would need to be re-established and opening of new markets would be difficult. This may threaten economic viability.
Non-commercial and environmental	B – Minor significance at the local level Physical, chemical and biological control methods have been shown to be effective in reducing infestation by *Deudorix* (Arora, Singh & Dhawan 2012; Bagle 2011; Gupta & Dubey 2005; Khan et al. 2017; Kumar & Gupta 2018; Paul 2007; Sharma & Batra 2007; Thakur et al. 1995; Yousuf, Ikram & Faisal 2015). Any additional usage of chemical sprays may affect the environment, but may not have any greater effect than present pest management methods.

4.2.8 Unrestricted risk estimate with pomegranate whole fruit

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

Unrestricted risk estimate for *Deudorix epijarbas* and *Deudorix Isocrates* on pomegranate whole fruit	
Overall likelihood of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very Low

The unrestricted risk estimates for *Deudorix epijarbas* and *Deudorix isocrates* on the pomegranate whole fruit from India pathway are assessed as ‘Very Low’, which achieves the ALOP for Australia. Therefore, no specific risk management measures are required for these pests on this pathway.

4.2.9 Unrestricted risk estimate with pomegranate processed arils

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

Unrestricted risk estimate for *Deudorix epijarbas* and *Deudorix Isocrates* on pomegranate processed arils	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Low
Unrestricted risk	Negligible

The unrestricted risk estimates for *Deudorix epijarbas* and *Deudorix isocrates* on the pomegranate processed arils from India pathway are assessed as ‘Negligible’, which achieves the

ALOP for Australia. Therefore, no specific risk management measures are required for these pests on this pathway.

4.3 Pomegranate aphid

Aphis punicae

Aphids are small sap-sucking insects in the order Hemiptera and superfamily Aphidoidea. A typical aphid life cycle involves flightless (apterous) females giving birth to living female nymphs without the involvement of mates. Maturing rapidly, females breed profusely, so that the number of these insects multiplies quickly (Simon, Rispe & Sunnucks 2002). Winged (alate) females may develop later in a season, allowing the insects to colonise new plants. In temperate regions, sexual reproduction occurs in the autumn, with the insects often overwintering as eggs. Aphids are among the most destructive insect pests on cultivated plants worldwide (Hullé et al. 2010). In addition to weakening the host plants by sucking sap, they act as vectors for plant viruses and disfigure ornamental plants with deposits of honeydew and subsequent growth of sooty moulds and attraction of ants.

Aphis punicae, commonly called the pomegranate aphid, is an economically important pest of pomegranate crops (Bayhan et al. 2005; Sreedevi & Verghese 2007a). Nymphs and adults colonise tender shoots, flower buds, flowers and young fruit, and suck sap from plant tissues. Infestation by *A. punicae* results in stunted growth and drying of tender parts. *Aphis punicae* also excretes copious amounts of honeydew, which provides a medium for the development of sooty mould and attracts ants (Sreedevi & Verghese 2007a). *Aphis punicae* has also been reported to be capable of transmitting viruses (Kahramanoglu & Usanmaz 2016).

Aphis punicae has high reproductive capacity, and is capable of producing offspring by sexual and asexual reproduction throughout the year. The entire life cycle of *A. punicae* takes 22 to 25 days, with 12 to 14 overlapping generations per year (Mescheloff & Rosen 1990; Swirski & Amitai 1999). The body of the wingless female is light green and the length of the female body is 1.0mm to 2.0mm. Winged females have a dark head and greenish body; their body length is 1.4mm to 1.9mm. On pomegranate, sexual forms occur and mate in winter, and females deposit eggs in the leaf axils. The nymphs that emerge in the following spring then mature and reproduce asexually until autumn.

Temperature is an important environmental parameter that affects the rates of development, reproduction, mortality, and survival (Bayhan et al. 2005). The optimal temperature for *A. punicae* reared on pomegranate is between 22.5°C to 25.0°C. At these temperatures, females produce about 30 progeny through sexual reproduction per year (Bayhan et al. 2005). The nymphal period lasts for seven to nine days, adults live for two to three weeks and produce eight to 22 nymphs per day by asexual reproduction.

Aphis punicae is a polyphagous pest (Plant Parasites of Europe 2019), but the main hosts of *A. punicae* are pomegranate, golden dewdrop (*Duranta repens*), and plumbago (*Plumbago capensis*) (Swirski & Amitai 1999). In addition, *A. punicae* is reported to be found less commonly on catalpa (*Bignonia species*), trumpet vine (*Campsis radicans*) and Indian lantana (*Lantana camara*) (Barbagallo et al. 2011; Barbagallo & Cocuzza 2014; Lampel & Meier 2007).

The development, survival and reproduction of *A. punicae* are reported to depend on temperature, with a mild temperature range of 25°C to 27°C reported to be optimal under laboratory conditions (Bayhan et al. 2005). The seasonal occurrence of *A. punicae* in pomegranate orchards in India is reported to peak during the cooler period from about November to February (Karuppuchamy, Balasubramanian & Sundara Babu 1998; Shevale &

Kaulgud 1998; Sreedevi & Verghese 2007b). There is no evidence for *A. punicae* entering diapause or quiescence during winter.

The geographic distribution of *A. punicae* includes countries from the temperate zones with cold winters, such as Korea and Japan (CABI 2020; Lee et al. 2015). However, it is likely that *A. punicae* has relatively low rates of growth and reproduction during unfavourable conditions (Sreedevi & Verghese 2007b).

Aphis punicae has been reported to be able to transmit viruses from other plant species and between pomegranate trees (Kahramanoglu & Usanmaz 2016). However, those authors did not identify any specific virus transmitted by *A. punicae*. The viruses identified in the pest categorisation in Appendix A-1 of this document in association with pomegranate in India—*Cucumber mosaic virus*, *Leafroll-associated virus 1* and *Tomato ringspot virus*—have not been shown to be transmitted by *A. punicae*.

Aphis punicae is reported to be present in India (Balikai, Kotikal & Prasanna 2009; Sreedevi & Verghese 2007b) and not present in Australia; therefore, it is a pest of biosecurity concern for all of Australia.

The risk scenario of biosecurity concern for *A. punicae* is the presence of nymphs and/or adult females on the pomegranate whole fruit pathway.

4.3.1 Likelihood of entry

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

Likelihood of importation

The likelihood that *Aphis punicae* will arrive in Australia with the importation of pomegranate whole fruit from India is assessed as: **Moderate.**

The following information provides supporting evidence for this assessment.

- *Aphis punicae* is widespread in India (Mall, Srivastava & Singh 2010; Mani & Krishnamoorthy 1995a, b; Sreedevi & Verghese 2007b), and reported in pomegranate growing areas, including Uttar Pradesh (Mall, Srivastava & Singh 2010), Karnataka (Biradar & Shaila 2004), Andhra Pradesh (Sreedevi & Verghese 2007a), Bangalore (Mani & Krishnamoorthy 1995b), South-western Punjab (Pathania et al. 2019), Meghalaya, Tamil Nadu and West Bengal (NBAIR 2019).
- *Aphis punicae* is an important pest of pomegranate in India. Nymphs and adults colonise tender shoots, flower buds, flowers and young fruit and suck sap from plant tissues, but under heavy infestations also feed on the mature fruits (Ananda, Kotikal & Balikai 2009; Lee et al. 2015).
- *Aphis punicae* has been reported to occur throughout the year although it has been noted to peak during the cooler period (Biradar & Shaila 2004; EI-Nagar, Ismail & Atlia 1982; Karuppuchamy, Balasubramanian & Sundara Babu 1998; Mohammad & Abdullah 1989; Shevale & Kaulgud 1998; Sreedevi & Verghese 2007b). Pomegranate is reported to be grown throughout the year in parts of India, which provides a continuous environment and potential for a high density of *A. punicae* throughout the year, possibly leading to infestation

of pomegranate fruit (Department of Agriculture and Water Resources 2018a; Government of India 2017b).

- The in-field crop practices (including pesticide spraying, routine inspection of orchards) and post-harvest handing practices, including air blowing and washing, may remove the majority of these external feeders, but are unlikely to completely eliminate the pest from pomegranate whole fruit.
- The winged *A. punicae* may be disturbed during fruit sorting and packing processes and may be removed from the pathway. However, the nymphs and wingless adults of *A. punicae* that are attached to the basal portion and folded calyx of the fruit could be difficult to remove.
- *Aphis punicae* excretes copious amounts of honeydew, which provides a medium for the development of sooty mould on the surface of fruit and attracts ants (Sreedevi & Verghese 2007a). These visible symptoms are likely to be detected during packing house quality control inspection. However, *A. punicae* is likely to be difficult to detect at low population levels where there is no visible damage to the fruit.
- It has been noted that some aphid species from the same genus, *Aphis nasturtii* and *Aphis gossypii*, can survive temperatures below –2°C for more than 25 days (Adams 1962). Aphid eggs are extremely cold-hardy; they have been reported to have super-cooling points of about –42°C (Leather 2014). These cold-tolerance characteristics make the pest likely to survive transportation of pomegranate whole fruit at the proposed temperature of 5°C to 8°C.

Aphis punicae is widespread in India and associated with pomegranate whole fruit, occurs throughout the year, is able to tolerate cold storage and transportation, and can be difficult to detect by visual inspection. However, use of appropriate orchard management practices such as monitoring and control, packing house processes such as washing, brushing and air-blowing of calyx, and inspection for symptoms of presence including honeydew accumulation and sooty mould build-up on fruit can moderate the risk. These factors collectively support a risk rating for importation of 'Moderate'.

Likelihood of distribution

The likelihood that *Aphis punicae* will be distributed in Australia in a viable state as a result of the processing, sale or disposal of the commodity and subsequently transfer to a susceptible host is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- Pomegranate whole fruit would be distributed for sale to various destinations in Australia. They may be distributed through large fresh produce wholesale markets and then to supermarkets or other sellers, or directly to smaller retailers and then to consumers.
- The nymphs and wingless adults of *A. punicae* may remain on the fruit during transportation to retail outlets to multiple destinations in Australia; therefore, infested pomegranate deliveries are likely to reach areas with susceptible host plants.
- During transportation, imported pomegranate whole fruit are likely to be kept at temperatures around 5°C to 8°C. The transit temperature is unlikely to be lethal for *A. punicae* as they are able to tolerate cold temperatures (Biradar & Shaila 2004). At retail

outlets, pomegranates are likely to be displayed at an ambient temperature that would support the survival and development of *A. punicae*.

- Pomegranates have a thick leathery rind and arils need to be extracted for consumption. Therefore, most infested pomegranate waste is likely to be disposed of as municipal waste, from where it is unlikely to distribute *A. punicae* into the environment. However, pomegranate waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetation.
- The condition of discarded non-edible pomegranate waste is expected to deteriorate quickly in the environment and may prevent nymphs from progressing to the adult stage. A study showed the optimal relative humidity for *A. punicae* is around 97% (Pathania et al. 2019). It is expected that discarded pomegranate fruit would lose moisture rapidly in Australia's dry climate.
- Pomegranate is the major host of *A. punicae*. Commercial pomegranate orchards have limited distribution in Australia. Moreover, pomegranate is a deciduous tree, which typically does not retain leaves during winter in temperate parts of Australia, and seasonally limits the availability of pomegranate hosts. *Aphis punicae* is reported to be found less commonly on catalpa (*Bignonia species*), trumpet vine (*Campsis radicans*) and Indian lantana (*Lantana camara*) (Barbagallo et al. 2011; Barbagallo & Cocuzza 2014; Lampel & Meier 2007).
- All life stages of *A. punicae* are able to move between their hosts (Bayhan et al. 2005). Wingless aphids were able to walk and reach plants up to 13.5m away from the release point in seven hours (Ben-Ari, Gish & Inbar 2015). Long distance dispersal by wind has been reported to transport aphids hundreds of kilometres (Loxdale et al. 1993).
- Some well-established theories of winged morph induction in aphids are reported. Less abundant host material and low temperatures were considered as the most robust stimulus for inducing winged morphs (Müller, Williams & Hardie 2001; White 1946). During transportation of pomegranate whole fruit, the pest is likely to be exposed to limited host materials and low temperatures, which may accelerate the induction of winged morphs.

Aphis punicae could survive storage and transportation with whole pomegranate fruit. They are independently mobile, and can also be dispersed by wind. The major host, pomegranate, has a limited distribution in Australia, and the possibility of the pest finding a host in a suitable growth phase is limited. Pomegranate rind, the part of the fruit with which the pest is associated, is disposed of as waste, which is likely to reduce pest survival and likelihood of finding a host. These factors collectively support a risk rating for distribution of 'Moderate'.

Overall likelihood of entry

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

The likelihood that *A. punicae* will enter Australia as a result of trade in pomegranate whole fruit from India and be distributed in a viable state to a susceptible host is assessed as: **Low**.

4.3.2 Likelihood of establishment

The likelihood that *Aphis punicae* will establish in Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- The main host of *A. punicae* is pomegranate. Pomegranate is grown as a fruit tree and ornamental shrub in Australian backyards. Commercial pomegranate production in Australia was estimated to be 500 hectares in 2014. Pomegranate orchards have been established in the Murray–Darling Basin, from southern Queensland (St. George), to southern New South Wales (Lachlan and Murrumbidgee valleys) and northern Victoria (Shepparton), to South Australia (Adelaide region, the Murray Mallee, Clare Valley and the South East), and in Western Australia, near Carnarvon and south of Perth (AgriFutures Australia 2017b).
- *Aphis punicae* is a polyphagous pest (Plant Parasites of Europe 2019), but the main hosts of *A. punicae* are pomegranate, golden dewdrop (*Duranta repens*) and plumbago (*Plumbago capensis*) (Swirski & Amitai 1999). In addition, *A. punicae* is reported to be found less commonly on catalpa (*Bignonia species*), trumpet vine (*Campsis radicans*) and Indian lantana (*Lantana camara*) (Barbagallo et al. 2011; Barbagallo & Cocuzza 2014; Lampel & Meier 2007).
- *Aphis punicae* has established in areas with a wide range of climatic conditions (Blackman & Eastop 2008). *Aphis punicae* has been reported from main pomegranate production areas worldwide, and is best suited to Mediterranean climates with cool winters and hot summers. Similar climatic conditions occur in many regions of Australia (Bureau of Meteorology 2013).
- *Aphis punicae* reproduces both sexually and asexually. Sexual forms produce an average of 30 eggs per female. The hatchability rate of these eggs has been reported to be over 90% (Bayhan et al. 2005). Asexual forms, where adult females give birth to live nymphs without mating, produce eight to 22 nymphs per day (Agropedia 2019). Up to 12 to 14 overlapping generations per year have been reported (Agropedia 2019). Asexual reproduction allows a single female aphid to rapidly establish a new colony without mating, consequently, an aphid population is able to reach economically significant levels at a rapid rate (Ben-Ari, Gish & Inbar 2015; Kahramanoglu & Usanmaz 2016).
- *Aphis punicae* populations have been observed to occur throughout the year, with increased occurrences in cooler months (EI-Nagar, Ismail & Atlia 1982; Karuppuchamy, Balasubramanian & Sundara Babu 1998; Mohammad & Abdullah 1989; Shevale & Kaulgud 1998; Sreedevi & Verghese 2007b).
- Existing control programs, such as insecticide application for other pests in pomegranate orchards, may have some impact on the establishment of *A. punicae*, but these measures are not commonly used in home gardens and amenity plantings.

The combination of availability of host plants, suitable climatic conditions, and significant reproductive potential including the occurrence of many generations per year and the capacity to asexually reproduce supports the likelihood of establishment in Australia. However, these factors are moderated by the limited distribution of the main host, pomegranate, and use of control measures for other pests that may impact on the establishment of *A. punicae*. These factors collectively support a risk rating for establishment of ‘Moderate’.

4.3.3 Likelihood of spread

The likelihood that *A. punicae* will spread, based on a comparison of key factors in the area of origin and in Australia that are likely to affect the expansion of the geographic distribution of the pest is assessed as: **High.**

The following information provides supporting evidence for this assessment.

- The reported hosts of *A. punicae*, including pomegranate, are grown in Australia (AVH 2020).
- *Aphis punicae* has a wide geographic distribution throughout the Mediterranean region, the Middle East, Egypt, Ethiopia, India, Indonesia, Japan, Iran, Iraq, Korea, Morocco and Pakistan (CABI 2020; Lee et al. 2015). These areas represent a range of different climatic zones and conditions similar to those in Australia.
- Although *A. punicae* is an exotic species to Korea, its recent establishment and spread in that country (Lee et al. 2015), indicates that this species probably has a relatively high level of dispersal potential.
- *Aphis punicae* nymphs and adults are able to move between host plants (Bayhan et al. 2005). Aphids have two natural modes of dispersal: flight by winged aphids and walking by wingless aphids (Ben-Ari, Gish & Inbar 2015).
- Winged and wingless aphids can be wind-borne over long distances; for example, interceptions of aphids have been reported hundreds of kilometres over deserts or seas (Loxdale et al. 1993). Many observational studies have shown that winged aphids are capable of migrating long distances (Kavallieratos et al. 2007; Parry 2013).
- *Aphis punicae* is a small and light-green coloured pest that is likely to be transported without detection with human-mediated movement of infested fruits and planting materials.
- Wingless aphids are likely to stay at the feeding site until high population densities result in lack of breeding and feeding niches, forcing aphids to disperse seeking a new host (Sreedevi & Abraham 2008). Wingless aphids have been reported to reach host plants up to 13.5m away from the release point in seven hours (Ben-Ari, Gish & Inbar 2015).
- *Aphis punicae* secretes copious amounts of honeydew which attracts ants. Many species of ants are known to interact with aphids, 'tending' or 'farming' aphid colonies in order to harvest honeydew as a food source. Ants have also been reported to transport aphids to new sites to other host plants and/or to avoid predators (Oliver et al. 2007; Wimp & Whitham 2001). However, the commonly reported ant species associated with *A. punicae*, such as *Lasius alienus* and *Lepisiota bipartite* are not known to occur in Australia (Kök et al. 2018; Shiran, Mossadegh & Esfandiari 2012).
- Natural barriers in Australia, including arid areas, climatic differences and long distances between pomegranate orchards and other hosts will limit the ability of *A. punicae* to disperse from one area to another unaided.
- The important predators of *A. punicae* in pomegranate orchards are hoverflies (*Ischiodon scutellaris*) and the eleven-spotted ladybird (*Coccinella undecimpunctata*) (Al-Deghairi et al. 2014; Sreedevi & Verghese 2007a). These natural enemies are present in Australia (Houston

1991). However, the potential effectiveness of natural enemies in Australia has not been reported.

Aphis punicae occurs in a wide range of climatic conditions. The winged form of the pest is highly mobile; all life stages could be wind-borne over long distances, could be transported through human-mediated mechanisms, and may have the potential to be carried by other organisms such as ants. Although some potential natural enemies are present in Australia, their possible effectiveness in limiting the spread of *A. punicae* is unknown. These factors support a risk rating for spread of 'High'.

4.3.4 Overall likelihood of entry, establishment and spread

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

The overall likelihood that *A. punicae* will enter Australia as a result of trade in pomegranate whole fruit from India, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is assessed as: **Low**.

4.3.5 Consequences

The potential consequences of the establishment of *Aphis punicae* in Australia have been estimated according to the methods described in Table 2.3.

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

Criterion	Estimate and rationale
Direct	
Plant life or health	D – Major significant at local level *Aphis punicae* is an economically important pest of pomegranate. Infestation by *A. punicae* affects the photosynthetic ability of host plants, consequently affecting the development of fruit and causing considerable yield loss (Abd-Ella 2015; Sreedevi et al. 2006). However, the extent of crop loss is not well reported in the literature. Affected host plants become discoloured and stunted (Sreedevi et al. 2006). A high population that lasted for more than two weeks on pomegranate trees was observed to result in stunted or weak trees (Kahramanoglu & Usanmaz 2016). *Aphis punicae* produces copious amounts of sticky honeydew on leaves and fruits, which serve as substrate for some fungi. This exudate turns black with the growth of sooty mould fungus (Kahramanoglu & Usanmaz 2016), which may make the fruit/plant susceptible to secondary infection by other insects/pathogens. The commercial pomegranate industry is relatively small in Australia, but is expected to expand. In 2014, pomegranate production areas totalled about 500 hectares (AgriFutures Australia 2017b). The Australian pomegranate industry regularly applies copper and sulphur chemicals to control pests and diseases (RIRDC 2014). There are registered insecticides available for use on pomegranate in Australia, which may help control *A. punicae*.
Other aspects of the environment	A – Indiscernible at the local level There are no known direct consequences of this species on the natural environment internationally, or predicted to occur domestically. High infestation rates have only been reported on pomegranate (Sreedevi & Verghese 2007b). There is no known direct consequences of this species on other native animals or plants.

Indirect	
Eradication, control	C – Significant at the local level Control and eradication may be feasible due to the limited host range. Control of *A. punicae* in the pomegranate orchard may be achieved through the use of insecticides, integrated pest management and growing practices. For example, in India, winter pruning of pomegranate trees for *A. punicae* control in orchards is highly recommended (Mdellel, Halima Kamel & Assadi 2015). However, eradication could be costly and could cause disruption to agribusiness and associated trades within the affected areas. It is possible that additional pest management in commercial pomegranate orchards may not be required, as existing measures against other arthropod pests may be effective against *A. punicae* in Australia. However, increased amounts of insecticide and additional crop management practices may be costly.
Domestic trade	C – Significant at the local level The Australian pomegranate industry is currently focused on the domestic market (AgriFutures Australia 2017b). If *A. punicae* became established in parts of Australia, it may have an effect at the local level due to trade restrictions on the sale or movement of pomegranates between states/territories.
International trade	B – Minor significance at the local level The commercial pomegranate industry is relatively small in Australia and focused on the domestic market (AgriFutures Australia 2017b), but is expected to expand (RIRDC 2008). Australia currently has market access for pomegranate fruit to Fiji, Indonesia, Nauru, Papua New Guinea, Qatar, Singapore, Tonga and the United Arab Emirates. If *A. punicae* became established in Australia, trading partners may review their phytosanitary requirements for affected commodities, including the possibility of suspending or stopping trade and/or imposing additional measures.
Non-commercial and environmental	B – Minor significance at the local level Insecticide applications or other control activities would be required to control this pest on susceptible crops, which could have minor impact on the environment. The introduction of *A. punicae* into Australia could potentially cause competition with native species. However, the impacts on native species is difficult to assess.

4.3.6 Unrestricted risk estimate

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

Unrestricted risk estimate for *Aphis punicae*	
Overall likelihood of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very Low

The unrestricted risk for *Aphis punicae* has been assessed as ‘Very Low’, which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for *Aphis punicae* on this pathway.

4.4 Almond mealybug

Drosicha dalbergiae

Drosicha dalbergiae is commonly referred to as 'almond mealybug'. *Drosicha dalbergiae* is not a mealybug as its name implies but is in fact a scale insect of the order Hemiptera and family Monophlebidae (Vea & Grimaldi 2016). It varies in size from 1mm to 5mm and grows beneath wax covers. As for the first instars of most species of scale insects, its nymphs emerge from the egg with functional legs and are called 'crawlers'. They immediately crawl around in search of a suitable habitat and start feeding. Adult female scales are almost always less mobile and permanently attached to the plant on which they feed.

Drosicha dalbergiae is commonly known as the 'almond mealybug' due to the similarity of its biological characteristics to mealybugs. *Drosicha dalbergiae* is an economically important insect pest as it sucks sap from the tender roots, branches and fruits of the host plants, causing loss of plant vigour, poor growth, leaf drop, and die-back of twigs and branches (Bhat, Koul & Bhat 1988). *Drosicha dalbergiae* incidence of up to 25% on pomegranate fruits was reported in Himachal Pradesh, India (Rawat, Pawar & Chand 1989).

The life stages of *D. dalbergiae* are eggs, nymphs and adults. The eggs are laid in the soil in clusters and covered with a cottony ovisac exhibiting a silky touch and appearance. Eggs measure 0.74mm ± 0.02mm in length and 0.4mm ± 0.5mm in breadth. The fecundity potential of *D. dalbergiae* ranges from 120 to 125 eggs per year per female, with a mean of 122.3 ± 0.6 eggs. Nymphal stages cover five instars. Newly emerged nymphs are active and yellowish-grey in colour, and the first nymphal stage persists from 170 to 180 days. The durations of second, third and fourth nymphal instars of *D. dalbergiae* vary between 15 to 19 days, 14 to 18 days and 30 to 42 days, respectively. Fifth instar nymphs are well developed and brownish-grey in colour, and their duration ranges from 16 to 22 days. Adult females are brownish-grey in colour, devoid of wings, sluggish and similar in shape to the last nymphal instar. However, adult males are more active and smaller in size, with a pair of wings. The adult females live for 10 to 23 days while males live for three to five days. The eggs and first instar nymphs overwinter in soil. Hatching of eggs in soil starts with a rise in ambient temperature, and the first instar nymphs feed on the roots of hosts. Once the conditions become favourable in the spring, emerged first instar nymphs crawl to the aerial parts of plants and feed on the inflorescences, tender leaves, shoots and fruits, and complete their development (Gul, Baba & Sherwani 2014; Koul et al. 2000).

The host plants of *D. dalbergiae* have been reported to include eight genera from seven families of plant species, including some economically important fruit crops such as apple, almond, pomegranate, mango and citrus (García Morales et al. 2016). *Drosicha dalbergiae* feeds on the phloem of host plants and excretes honeydew that covers the leaves, trunk and fruits. Therefore, in addition to direct damage to host plants, the pest makes fruit unmarketable due to the development of black sooty mould (Gul, Baba & Sherwani 2014).

Drosicha dalbergiae is reported to be present in India (Rawat, Pawar & Chand 1989) and not present in Australia; therefore, it is a pest of biosecurity concern for all of Australia.

The risk scenario of biosecurity concern for *D. dalbergiae* is the presence of nymphs and/or adult females on the pomegranate whole fruit pathway.

4.4.1 Likelihood of entry

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

Likelihood of importation

The likelihood that *Drosicha dalbergiae* will arrive in Australia with the importation of the pomegranate whole fruit is assessed as: **High**.

The following information provides supporting evidence for this assessment.

- *Drosicha dalbergiae* is recorded from the Indian states of Himachal Pradesh, Jammu and Kashmir, Punjab, Uttarakhand and Tamil Nadu, where pomegranates are grown (Gaffar 1989; Rawat, Pawar & Chand 1989; Suresh & Mohanasundaram 1996; Varshney, Jadhav & Sharma 2015; Vijay et al. 2000).
- *Drosicha dalbergiae* infestation is generally noticed on pomegranate whole fruit surface but the maximum damage occurs on the basal part of the fruits attached to the stem, throughout the season (Kaith 2001; Rawat, Pawar & Chand 1989).
- *Drosicha dalbergiae* colonises to form a white cluster and excretes a sticky honeydew on the fruit surface on which secondary fungal infection may develop (Rawat, Pawar & Chand 1989). These visible symptoms may be detected during packing house quality control inspections. However, *D. dalbergiae* is difficult to detect at low population levels, where there may be no visible damage on the fruit.
- Adult males of *D. dalbergiae* have wings and are not covered by wax, and therefore may be readily disturbed during fruit sorting and packing house processes and removed from the pathway. However, the later instar nymphs and adult females of *D. dalbergiae* form white clusters on the fruit and are largely non-mobile (Rawat, Pawar & Chand 1989).
- Infestations of *D. dalbergiae* on the basal part of the fruit attached to the stem (Rawat, Pawar & Chand 1989) makes them difficult to detect during fruit sorting and packing processes.
- *Drosicha dalbergiae* is reported to persist at low temperatures in northern India, and overwinter as a first instar, indicating this pest is cold tolerant, and therefore that it is likely to survive during transportation of pomegranate whole fruit from India at the proposed temperature of 5°C to 8°C.

Drosicha dalbergiae is present in pomegranate growing areas in India and causes damage to pomegranate whole fruit. Winged males could be disturbed during packing house processes and are unlikely to remain associated with fruit. Visible symptoms such as honeydew on the fruit surface may be detected; however, relatively sessile females and older nymphs, especially at the basal part of the whole fruit, are less likely to be detected. Incidence of this pest in the colder parts of India indicates its capacity to survive storage and transport. These factors support a risk rating for importation of 'High'.

Likelihood of distribution

The likelihood that *Drosicha dalbergiae* will be distributed in Australia in a viable state as a result of the processing, sale or disposal of the commodity and subsequently transfer to a susceptible part of a host is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- Pomegranate whole fruit would be distributed for sale to various destinations in Australia. They may be distributed through large fresh produce wholesale markets and then to supermarkets or other sellers, or directly to smaller retailers and then to consumers.
- The later instar nymphs and adult females of *D. dalbergiae* may remain on the fruit during retail sale and distribution to multiple destinations in Australia.
- During transport and distribution, imported pomegranate whole fruit are likely to be kept at cool temperatures. The transit temperatures are unlikely to be lethal for *D. dalbergiae* as they are able to tolerate cold temperatures as shown by the presence in some of the cooler pomegranate growing regions in India, including Himachal Pradesh, Jammu and Kashmir. At retail outlets, pomegranate whole fruit may be displayed at ambient temperatures that would support the survival and development of *D. dalbergiae*.
- Infested pomegranate waste is likely to be disposed of as municipal waste, from where it is unlikely to distribute *D. dalbergiae* into the environment. However, pomegranate waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetation.
- Some reported host plants of *D. dalbergiae*, such as apple, almond, mango, pomegranate and citrus, are grown in many parts of Australia. Alternative hosts of *D. dalbergiae*, such as guava and lychees and *Eugenia* species, are also grown in some parts of Australia (AVH 2020). As well as in commercial orchards, host plants can be commonly found in backyards and on roadsides across Australia, which would aid *D. dalbergiae* to find hosts.
- Unlike typical mealybugs and armoured scales, all life stages of *D. dalbergiae* are able to move to find a host (Koul et al. 2000). Although adult males have wings, they are short-lived, and therefore likely to travel only short distances. The main dispersal stage of *D. dalbergiae* is as first instar nymphs ('crawlers') that move by crawling and can also be carried by the wind.

Drosicha dalbergiae is likely to survive storage and transport, especially as wingless females and nymphs, and could be distributed with pomegranate whole fruit. First instar nymphs can move short distances by crawling and be dispersed via air currents over longer distances. The pest has a range of hosts distributed widely across Australia. However, likely disposal of pomegranate waste through municipal waste systems and the relatively fragile nature of the pest will make it less likely to find a suitable host. These factors collectively support a risk rating for distribution of 'Moderate'.

Overall likelihood of entry

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

The likelihood that *D. dalbergiae* will enter Australia as a result of trade in pomegranate whole fruit from India and be distributed in a viable state to a suitable host is assessed as: **Moderate.**

4.4.2 Likelihood of establishment

The likelihood that *D. dalbergiae* will establish based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as: **High**.

The following information provides supporting evidence for this assessment.

- Plant species from eight genera from seven families have been recorded as hosts of *D. dalbergiae* (García Morales et al. 2016). *Drosicha dalbergiae* has been reported as a key pest of apple (Khan et al. 2018), pomegranate (Rawat, Pawar & Chand 1989), almond and other stone and nut fruits (Vijay et al. 2000). *Drosicha dalbergiae* has also been recorded as a minor pest of citrus (Butani 1976). Apples, almonds, mango and citrus are widely grown in parts of Australia, which would aid *D. dalbergiae* to establish.
- *Drosicha dalbergiae* has been reported in many Indian pomegranate growing states (Rawat, Pawar & Chand 1989; Suresh & Mohanasundaram 1996; Varshney, Jadhav & Sharma 2015; Vijay et al. 2000), and also in Taiwan (García Morales et al. 2016). Relevant temperatures in India vary from 6°C to 37°C in summer and from −15°C to 15°C in winter. Taiwan is situated in a subtropical climate zone, with warm winters and hot summers. The climatic conditions of Australia represent several climatic zones, including tropical, subtropical and temperate zones that would support the establishment of *D. dalbergiae*.
- *Drosicha dalbergiae* produces one generation per year, with adult females each laying an average of 120 to 125 eggs under the scale cover (Vea & Grimaldi 2016). The hatching rate has been reported at 91% to 94%, with an average of 91.8% ± 0.42% (Gul, Baba & Sherwani 2014).
- *Drosicha dalbergiae* feeds both on aerial and underground parts of plants (Gul, Baba & Sherwani 2014). In addition, eggs and first instar nymphs survive in the soil during winter. The first instar nymphs have been found as deep as 68.5cm underground (Koul et al. 2000), where general soil insecticides are less likely to reach. The later instar nymphs and adult females are protected underneath a waxy or cottony covering, which serves as a barrier to traditional contact insecticides.
- Most scale insects are small and inconspicuous. *Drosicha dalbergiae* is an oddly-shaped and less mobile pest that often resembles shell-like bumps rather than an insect. In many cases, heavy infestations build-up unnoticed before host plants begin to show damage, which could aid *D. dalbergiae* to survive during crop inspections at the early stages of infestation.
- Existing control measures, such as insecticide application for mealybugs in apple and almond orchards in Australia, may have some impact on the establishment of *D. dalbergiae*, but these measures are not commonly used in home gardens and amenity plantings.

Drosicha dalbergiae has a range of hosts widely distributed in Australia and possesses a suitable reproductive strategy for establishment. Climatic conditions in Australia are unlikely to limit the establishment, while the development of eggs and first instars in soil may aid the survival of this pest in harsher environmental conditions. It is likely that any pest infestation may go unnoticed until the pest is well established due to its shape and size. Existing pesticide application practices may limit its establishment; however, their effectiveness specifically on *D. dalbergiae* is unknown. These factors support a risk rating for establishment of 'High'.

4.4.3 Likelihood of spread

The likelihood that *D. dalbergiae* will spread, based on a comparison of key factors in the area of origin and in Australia that are likely to affect the expansion of the geographic distribution of the pest is assessed as: **High**.

The following information provides supporting evidence for this assessment.

- The commercial host fruit crops of *D. dalbergiae* such as apple, almond, pomegranate, mango, and citrus are grown in many parts of Australia, including in home gardens, in parks and along roads, which would aid the spread of *D. dalbergiae*.
- Unlike typical mealybugs and armoured scales, all life stages of *D. dalbergiae* are able to move within their host and between their hosts and the soil (USDA 2010). Adult males have wings, but are very fragile and short-lived and only travel for short distances (USDA 2010).
- The main natural dispersal stage of *D. dalbergiae* is the first instar nymph (crawlers), which can be carried by the wind. Crawlers of some species of scale have been reported to be dispersed by air currents for up to a few hundred kilometres from the infested trees (Gullan 1997; Hommay et al. 2019; Pasek 1988).
- As it is inconspicuous and attached firmly to an infested host, *D. dalbergiae* is likely to spread with human-mediated movement of infested materials. As eggs and the first instar nymphs are able to survive in the soil and feed on roots, the movement of nursery stock with soil is likely to aid the dispersal of *D. dalbergiae*.
- Apart from wind- and human–mediated dispersal, crawlers and eggs of scale insects have been reported to be dispersed by small rodents, birds and dogs (Greathead 1997; Washburn & Frankie 1981).
- Natural barriers in Australia, including arid areas, climatic differences and long distances between areas with suitable hosts may limit *D. dalbergiae*'s unaided dispersal. However, human-mediated movement of propagative material and infested fruit could aid its long-distance dispersal, although this may be mitigated to some extent through interstate biosecurity controls on the movement of nursery stock and horticulture commodities.
- Natural enemies, including seven-spot ladybird (*Coccinella septempunctata*), lady beetle (*Harmonia dimidiata*), green lacewing (*Chrysopa orestes*), common lacewing (*Chrysoperla carnea*), and a potential parasitoid, *Cryptochetum* sp., were found to be associated with *D. dalbergiae* (CABI 2020; Koul et al. 2000). These natural enemies are present in Australia; however, the potential impacts of these natural enemies have not been reported.

Drosicha dalbergiae has a range of hosts widely distributed in Australia. All life stages can move while first instars, in particular, can be spread by wind over long distances. The scale insect can spread via human-mediated movement and some other vertebrate vectors. Australia's natural geographic features such as climatic differences and long distances between suitable hosts may act as barriers and known natural enemies may have some impact on the spread of this pest. These factors collectively support a risk rating for spread of 'High'.

4.4.4 Overall likelihood of entry, establishment and spread

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

The overall likelihood that *D. dalbergiae* will enter Australia as a result of trade in pomegranate whole fruit from India, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is assessed as: **Moderate**.

4.4.5 Consequences

The potential consequences of the establishment of *D. dalbergiae* in Australia have been estimated according to the methods described in Table 2.3.

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

Criterion	Estimate and rationale
Direct	
Plant life or health	D – Significant at the district level *Drosicha dalbergiae* is polyphagous, feeding on eight genera from seven plant families (Ali 1968; García Morales et al. 2016). Most of these hosts are widespread in Australia, including apple, almond and citrus (AVH 2020). *D. dalbergiae* sucks sap from the tender roots, branches and fruits of the host plants, causing loss of plant vigour, poor growth, leaf drop, and die-back of twigs and branches (Bhat, Koul & Bhat 1988). There is little information about the economic impact of *D. dalbergiae.* It has been reported to infest up to 25% of pomegranate fruit in India (Rawat, Pawar & Chand 1989). On almond, *D. dalbergiae* reduces nut yield and quality (Koul et al. 2000). On apple, it was reported to be one of the most serious pests (Bhat, Koul & Bhat 1988), but economic data is not available. Besides causing direct damage, *D. dalbergiae* also secretes a sticky honeydew on which a fungus can develop. Consequently, infested fruit become brown and black and are unfit for consumption or marketing (Vea & Grimaldi 2016). Although *D. dalbegiae* is reported on crops, including almond, apple and citrus, existing control practices for other species of scale insects on these crops (Hardy 2004; Hetherington 2009; Manners 2016; SACOA 2020) may also control *D. dalbergiae* in Australian orchards. The commercial pomegranate industry is small in Australia, but it is expected to expand (AgriFutures Australia 2017b). In 2014, there were about 500 hectares of commercial pomegranate orchards in Australia producing about 4,000 tonnes a year. The Australian almond crop produced 75,000 tonnes and exported 54,343 tonnes to the established markets of Europe, India, the Middle East and North-East Asia in the 2017/2018 season (Australian almonds 2019). Australia produces on average 300,000 tonnes of apples per year, almost all of which is consumed domestically.
Other aspects of the environment	A – Indiscernible at the local level There are no known direct consequences of this species on the natural environment. High infestation rates have only been reported on pomegranate and almond (Rawat, Pawar & Chand 1989; Vijay et al. 2000). There are no reported direct consequences of this species on other animals and plants.
Indirect	
Control, eradication, etc.	D- Significant at the district level Eradication may be feasible if infestations are detected before *D. dalbergiae* has spread widely. Eradication actions could be costly and would cause disruption to agribusiness and associated trades. Additional pest management measures in commercial orchards may not be required, as existing measures against other common scales and mealybugs may be effective against *D. dalbergiae* in Australia. However, increased amounts of insecticides and additional crop management practices may be required.
Domestic trade	D – Significant at the district level The commercial pomegranate industry is small in Australia, but expected to expand. The Australian pomegranate industry is currently focused on the domestic market (AgriFutures Australia 2017b). However, the industries of apple, almond and citrus are economically more important in Australia (AVH 2020).

	If *D. dalbergiae* were to become established in parts of Australia, it may have a significant effect at the local level due to resulting potential trade restrictions on the sale or movement of apples, almond, pomegranates and citrus between states/territories.
International trade	C – Significant at the local level Australia currently has market access for pomegranate fruit to Fiji, Indonesia, Nauru, Papua New Guinea, Qatar, Singapore Tonga and the United Arab Emirates. Meanwhile, Australian apple, citrus and almond have a broad range of international markets and are exported in large quantities to many countries. As *D. dalbergiae* has only been reported from India and Taiwan. If *D. dalbergiae* was to establish in Australia, trading partners may review their phytosanitary requirements for affected commodities. The measure for an externally feeding pest is typically consignment inspection. Of the 75,000 tonnes of the almond crop produced, 54,343 tonnes were exported to the established markets of Europe, India, the Middle East and North-East Asia in the 2017/2018 season (Australian almonds 2019). Almost all of the 300,000 tonnes of apples produced on average per year are consumed domestically, with only about 1% to 2% of the production exported to Papua New Guinea, the United Kingdom, Asia, the United Arab Emirates and Thailand (AgriFutures Australia 2017a). The Australian citrus industry is the largest exporter of fresh produce in the Australian horticulture sector with an average of 120,000 tonnes of oranges and 30,000 tonnes of mandarins exported annually (Citrus Australia 2019).
Environment	B – Minor significance at the local level Insecticide applications or other control activities would be required to control this pest on susceptible crops, which could have minor indirect impact on the environment. The introduction of *D. dalbergiae* into Australia may cause competition with native species. However, the possible level of impacts on native species is difficult to assess.

4.4.6 Unrestricted risk estimate

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

Unrestricted risk estimate for *Drosicha dalbergiae*	
Overall likelihood of entry, establishment and spread	Moderate
Consequences	Low
Unrestricted risk	Low

As indicated, the unrestricted risk for *D. dalbergiae* has been assessed as 'Low', which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *D. dalbergiae* on this pathway.

4.5 Pomegranate mite and Pomegranate false spider mite

Tenuipalpus granati and *Tenuipalpus punicae*

Tenuipalpus granati and *Tenuipalpus punicae* belong to the family Tenuipalpidae and are economically important pest species on pomegranate (Al-Gboory & El-Haidari 1988; Gupta & Srivastava 1991; Jeppson, Keifer & Baker 1975). Of the 1,250 species recorded worldwide in this family, only 66 have been recorded from Australia (ABRS 2019). Tenuipalpid mites superficially appear very similar to spider mites, although they lack the ability to produce silk webbing, and are therefore commonly referred to as 'false spider mites' or 'flat mites' (Ueckermann et al. 2018). *Tenuipalpus granati* and *Tenuipalpus punicae* are grouped together for this risk assessment because of their similar habits and biologies, on the basis of which they are predicted to pose similar biosecurity risks and, therefore to require similar management measures. In this assessment, the term 'false spider mites' is used to refer to these two species. The scientific name is used when information refers specifically to one of the species.

False spider mites infest fruit trees, cereal grains, vegetable crops such as mangoes, grapes, guava, citrus, and *Prunus* species, as well as rice, pulses, sugarcane, cotton and some ornamentals (Abdelgayed et al. 2017; Gupta 1985; Vacante & Kreiter 2018). The feeding activity of tenuipalpid mites causes direct and severe damage to economically important plants, and may facilitate disease entry via physical wounds inflicted on host plants.

Tenuipalpus granati has been reported on pomegranates in Egypt, Israel, Iran and India (Al-Gboory & El-Haidari 1988; Menon, Ghai & Katiyar 1971), usually on the lower leaf surfaces along the midrib and veins (Vacante 2016), and on pomegranate fruits (Hatzinikolis 1986). It has also been reported on grapes in Azerbaijani, Egypt, Georgia, Greece and Kazakhstan (Jeppson, Keifer & Baker 1975).

Tenuipalpus punicae has been reported on pomegranate leaves and fruits, causing fruit cracking (Al-Gboory & El-Haidari 1988; Hatzinikolis 1986; Jeppson, Keifer & Baker 1975). It has a wide geographic range and has been considered the most serious pest of pomegranate in Iraq (Al-Gboory & El-Haidari 1988).

False spider mites have five life stages: egg, larva, two nymphal stages (protonymphal and deutonymphal) and adult (Yousef, Zaher & El-Hafiez 1980). Adult females of false spider mites generally emerge in mid-autumn and after hibernating for up to 122 days during winter, start depositing eggs on the striations and natural indentations of leaves (Amini 2008; Yousef, Zaher & El-Hafiez 1980). The infestation of tenuipalpid mites on pomegranates in India is evident throughout the year, and the population density of false spider mites is dependent on seasonal variation (Amini 2008; Prabheena 2015). However, the most suitable conditions for tenuipalpid mites in India are observed at a temperature of about 30°C, in combination with a relative humidity of about 70% (Amini 2008; Prabheena 2015). The incidence of false spider mites in India was found to peak from February to May, with minimum populations observed in July (Amini 2008; Ghoshal, Barman & Saha 2011). This correlates positively with temperature and relative humidity, and negatively with rainfall (Ghoshal, Barman & Saha 2011).

False spider mites prefer lower leaf surfaces and may cause stippling of injured tissue, as well as leaf and fruit drop or twig die-back (Al-Gboory & El-Haidari 1988; Yousef, Zaher & El-Hafiez 1980).

Tenuipalpus granati and *Tenuipalpus punicae* are reported to be present in India (Balikai, Kotikal & Prasanna 2009) and not present in Australia; therefore, they are pests of biosecurity concern for all of Australia.

The risk scenario of biosecurity concern for false spider mites is that the eggs, nymphs and/or adults may be present on the pomegranate whole fruit pathway (Al-Gboory & El-Haidari 1988; Hatzinikolis 1986; Jeppson, Keifer & Baker 1975).

The species *Tenuipalpus zhizhilashviliae* has been assessed previously, for the pathway of fresh persimmon fruit from Japan, Korea and Israel (DAFF 2004c). The unrestricted risk estimate for *T. zhizhilashviliae* was assessed as 'Negligible', which achieves the ALOP for Australia. Therefore, specific risk management measures were not required for this pest on the pathway.

Although the pest biologies and predicted biosecurity risks for *T. granati* and *T. punicae* are considered to be similar to that of *T. zhizhilashviliae*, the differences in commodity pathways, horticultural practices, climatic conditions, regional prevalence and host plants of these two species, as compared to the one considered in existing policy, make it necessary to separately assess the risk posed by these two species on the pomegranate whole fruit from India pathway.

4.5.1 Likelihood of entry

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

Likelihood of importation

The likelihood that false spider mites will arrive in Australia with the importation of pomegranate whole fruit from India is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- False spider mites are pests of pomegranate and have been reported from the pomegranate production areas of India. False spider mites infest leaves, flowers and fruits of pomegranates (Ananda, Kotikal & Balikai 2009; Çobanoğlu, Ueckermann & Sağlam 2016; ICAR 2012; Kotikal, Ananda & Balikai 2011; Menon, Ghai & Katiyar 1971).
- Eggs and larvae of false spider mites could be present on fruit, and nymphs and adults can feed on fruit (Al-Gboory & El-Haidari 1988; Hatzinikolis 1986).
- False spider mites are minute, measuring about 0.2mm to 0.3mm in length (Vacante & Kreiter 2018); on fruit, they generally hide in protected areas such as calyx. Packing house processes are likely to remove some but not all mites associated with fruit.
- Adult false spider mites overwinter in cool climates in cracks and under the bark of trees, and are known to occur on fruit (Al-Gboory & El-Haidari 1988; Hatzinikolis 1986; Yousef, Zaher & El-Hafiez 1980). They may possibly survive storage and transport conditions, as pomegranate whole fruit are proposed to be transported at 5°C to 8°C.

False spider mites are pests of pomegranate and present in pomegranate growing areas of India. Harvesting and packing house processes are likely to minimise the presence of these small external pests on the fruit, although there is a possibility that some, especially as eggs and nymphs present in the fruit calyx, could escape detection. The mites may be able to survive storage and transport at cold temperatures. These factors collectively support a risk rating for importation of 'Moderate'.

Likelihood of distribution

The likelihood that false spider mites will be distributed in Australia in a viable state as a result of the processing, sale or disposal of pomegranate whole fruit and subsequently transfer to a susceptible host is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- Pomegranate whole fruit would be distributed for sale to various destinations in Australia. They may be distributed through large fresh produce wholesale markets and then to supermarkets or other sellers, or directly to smaller retailers and then to consumers. Mites present on pomegranate are likely to occupy sheltered positions, such as the stem attachment and the calyx.
- Pomegranates have a thick leathery rind and arils need to be extracted for consumption. As any infested pomegranate waste is likely to be disposed of as municipal waste, the mites are unlikely to move into the environment. However, pomegranate waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetation.
- Tenuipalpid mites do not fly, and have a low likelihood of moving from fruit waste to a host by crawling because of their small size. However, false spider mites have been reported to move immediately after hatching to feeding sites and to spread to different canopy levels and between host plants (Amini 2008). While there is limited literature on the mode of locomotion of the two species assessed here, other spider mites have also been reported to be able to access hosts in the environment via air currents (Amini 2008; Pedgley 1982).
- False spider mites have been isolated from a wide range of host plants which are present in Australia and widely distributed. Host plants include cherry (*Prunus avium*), lemon (*Citrus limonum*), grapes (*Vitis vinifera*), fig (*Ficus carica*), pomegranate (*Punica granatum*), quince (*Cydonia oblanga*), walnut (*Juglans regia*), and nursey and amenity trees such as French hydrangea (*Hydrangea hortensia*) and willow (*Salix* pp.) (Hatzinikolis 1986; Hatzinikolis & Emmanouel 1987). The presence of hosts on roadsides and in home gardens, parks and orchards would assist the successful distribution of these false spider mites.

It is possible that false spider mites that may be present on the fruit could reach various parts of Australia via distribution of the fruit for sale. While potential hosts are present in many parts of Australia, the end use of consumption and likelihood of fruit waste that could potentially carry these pests being disposed in municipal waste systems will minimise the likelihood of the pest transferring to a suitable host. The likelihood will be further minimised by the mites' limited mobility and reliance on other mechanisms such as wind to be carried in the environment. These factors collectively support a likelihood estimate for distribution of 'Moderate'.

Overall likelihood of entry

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

The likelihood that false spider mites will enter Australia as a result of trade in pomegranate from India, and be distributed in a viable state to a susceptible host, is assessed as: **Low**.

4.5.2 Likelihood of establishment

The likelihood that false spider mites will establish in Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as: **High**.

The following information provides supporting evidence for this assessment.

- A large number of host plant species are widely distributed in Australia. False spider mites are capable of feeding on a range of fruit crops such as cherry (*Prunus avium*), lemon (*Citrus limonum*), grapes (*Vitis vinifera*), fig (*Ficus carica*), pomegranate (*Punica granatum*), quince (*Cydonia oblanga*), walnut (*Juglans regia*) and nursey plants such as French hydrangea (*Hydrangea hortensia*) (Hatzinikolis 1986). Host availability in urban and rural areas is high in southern parts of Australia (Hnatiuk 1990).
- Suitable environmental conditions for establishment exist in Australia. In India, overwintering populations of false spider mites are adult females, which produce successive generations the following spring (Amini 2008; Prabheena 2015). If gravid female false spider mites were to be distributed in Australia via pomegranate fruit they may be capable of establishing a new generation.
- Both species of the false spider mites assessed here occur in a range of climatic zones, including arid tropical and subtropical areas in north Africa, arid subtropical and warm temperate in the Middle East, and cold temperate to subarctic areas in the Middle East, North Asia and Eastern Europe (Al-Gboory & El-Haidari 1988; Vacante 2016). Within Australia, false spider mites may be capable of occupying a range of habitats in subtropical and temperate areas throughout southern Australia where suitable hosts also grow, often as naturalised plants (Al-Gboory & El-Haidari 1988; Hnatiuk 1990).
- Tenuipalpid mites have a suitable reproductive strategy for establishment in Australia. Developmental times for a single generation of false spider mites (egg to mature adult) for both species range from 21 to 32 days. Male mites develop relatively faster than females and the development is faster during warmer seasons. Pairing occurs soon after adult emergence and both sexes pair more than once (Amini 2008; Yousef, Zaher & El-Hafiez 1980).
- The number of generations completed by Tenuipalpid mites varies according to climate. Populations in cold temperate Europe complete one generation annually (Jeppson, Keifer & Baker 1975), while as many as eight generations were reported for both species in warm temperate to subtropical climates in Egypt and Iraq (Al-Gboory & El-Haidari 1988; Yousef, Zaher & El-Hafiez 1980). Populations of false spider mites introduced to Australia may be capable of breeding in most months of the year, especially in subtropical areas.
- The presence of false spider mites, if introduced to Australia, may not be immediately identified, as feeding damage is often not evident until considerable damage has occurred (Audenaert et al. 2018; Manners 2015). This is likely to be especially important for populations establishing on wild fruit trees in regional areas (Vacante 2016). This may allow populations of false spider mites to rapidly reach high numbers.

- Control measures for other mite species in orchards in Australia may have some impact on the establishment of false spider mites, but these measures are not commonly used in home gardens and amenity plantings.

False spider mites have a large range of host plants widely distributed across Australia and suitable environmental conditions exist for their establishment. These pest species have suitable reproductive strategies suitable for establishment with the possibility of producing multiple generations in areas with extended warmer climates and the ability to survive harsh conditions by overwintering. Their presence may not be immediately identified until considerable damage has been caused to the host species. Control measures for other mite species may have some impact on the establishment of these two species; however, these measures are not commonly used in home gardens. These factors collectively support a risk rating for establishment of 'High'.

4.5.3 Likelihood of spread

The likelihood that false spider mites will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- Host plants are widely grown across Australia. The distribution of hosts on roadsides and in home gardens, parks and orchards could assist the spread of these mites.
- Suitable environmental conditions for spread exist in Australia. Both species of false spider mites occur in many subtropical and temperate parts of Asia, Europe, North America and Africa (Al-Gboory & El-Haidari 1988; Vacante 2016). This indicates that there would be suitable environments for their spread in Australia.
- The presence of natural barriers such as arid areas, mountain ranges, climatic differentials and possible long distances between suitable hosts in parts of Australia may limit the spread of the two pest species.
- False spider mites have limited dispersal strategies for short- and long-distance spread. Crawling is the common mode of movement of the mites on host plants and this limits their ability to spread geographically.
- However, false spider mites have been reported to move immediately after hatching and to spread to different canopy levels and between host plants (Amini 2008). While there is limited literature on the mode of locomotion of the two species assessed here, other spider mites were reported to be able to access hosts as far as 2km apart via air currents (Amini 2008; Pedgley 1982).
- Distribution of infested pomegranate fruit and propagative host material around the country could facilitate human-mediated spread of these mites. However, biosecurity controls on the movement of nursery stock and horticulture commodities in Australia may reduce the likelihood of interstate spread of these pests.
- Known natural enemies of false spider mites are predatory mites; however, data on predatory mites are often scarce, and the controlling effect of natural enemies has seldom been determined. A recent study on predatory mites of India reported 33 species of

predatory mites (Mitra, Acharya & Ghosh 2017). None of those mites reported from India that specifically predate on the Tenuipalpidae family are present in Australia (Hung et al. 2011; Mitra, Acharya & Ghosh 2017). Although nine other predatory mites of the Tenuipalpidae family are established in Australia (James & Whitney 1993), the relatively low presence of natural enemies in Australia may allow plant-feeding populations of false spider mites to increase rapidly.

False spider mites would find suitable environmental conditions and host plants available in Australia. These pests have limited dispersal mechanisms and are unlikely to spread for long distances by crawling, although air currents could carry them for some distance. However, natural barriers may prevent such spread. Biosecurity controls on the movement of propagative material and horticulture commodities in Australia may further reduce the likelihood of long-distance spread. Predatory mites are known to occur in Australia; however, their effectiveness in controlling these pest mites is unknown. These factors collectively support a risk rating for spread of 'Moderate'.

4.5.4 Overall likelihood of entry, establishment and spread

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

The likelihood that false spider mites will enter Australia as a result of trade in pomegranate from India, be distributed in a viable state to a susceptible host, establish in Australia, and subsequently spread within Australia is assessed as: **Low**.

4.5.5 Consequences

The potential consequences of the establishment of false spider mites in Australia have been estimated according to the methods described in Table 2.3.

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

Criterion	Estimate and rationale
Direct	
Plant life or health	E – Significant at the regional level False spider mites feed on many fruit trees, vegetable crops and ornamentals including grapes, guava, citrus, *Prunus* species and hydrangea (Abdelgayed et al. 2017; Gupta 1985; Hatzinikolis 1986; Vacante & Kreiter 2018), which are widely grown in Australia and some of which are economically important fruit crops. They feed on leaves, soft twigs and fruits (Ananda, Kotikal & Balikai 2009; ICAR 2012; Menon, Ghai & Katiyar 1971). The pest species were reported to cause crop loss in Iraq, Egypt, Greece and Israel (Al-Gboory & El-Haidari 1988; Hatzinikolis 1986; Jeppson, Keifer & Baker 1975). In Australia in 2014 the pomegranate production area totalled about 500 hectares in the Murray–Darling Basin, from southern Queensland (St. George), to southern New South Wales (Lachlan and Murrumbidgee valleys) and northern Victoria (Shepparton), to South Australia (Adelaide region, the Murray Mallee, Clare Valley and the South East), in Western Australia, near Carnarvon and south of Perth (AgriFutures Australia 2017b). The industry is expected to grow.
Other aspects of the environment	B – Minor significance at the local level There are no known direct consequences of this species on the natural or built environment, but its introduction into a new environment may lead to competition for

	resources with native mite species. Loss in plant vigour and the potential for defoliation of amenity plants may have effects in urban areas.
Indirect	
Eradication, control	D – Significant at the district level It is expected that efforts would be required to contain and possibly eradicate an incursion of the two false spider mites within Australia. The indirect effects of eradication or control as a result of the introduction of false spider mites may include: (i) an increase in the use of acaricides for control of the pest due to uncertainty around critical times of application, (ii) disruption to integrated pest management programs due to the increased need to use acaricides, (iii) potential to develop resistance to acaricides as a result of the use of numerous applications of active ingredient, (iv) impacts of use of additional control measures on existing production practices, (v) increases in costs of production that alter the economic viability of some crops, and (vi) additional cost of crop monitoring and consultative advice to producers. However, other mite control measures already in use could potentially have some impact on these two species, and predatory mites present in Australia could potentially contribute towards eradication and control.
Domestic trade	D – Significant at the district level The indirect impact of false spider mites on domestic trade would be significant at the district level, resulting in an impact score of 'D'. This is because the impact could be expected to lead to a minor decrease in trade. The presence of false spider mites is likely to result in interstate trade restrictions on many commodities such as pear, quince, loquat, apricot, plum and pomegranate, and potential loss of markets. While this could require significant industry adjustment, it is not expected that the pest would result in a complete loss of markets. The measures that are available to control false spider mites would increase costs to manage and inspect for the pest.
International trade	D – Significant at the district level The impacts on plant life and/or health of the presence of false spider mites in commercial production areas of a wide range of commodities (e.g. pear, quince, loquat, apricot, plum and pomegranate) may limit access to overseas markets where the pest is not present. Because measures are available to mitigate false spider mites, it is not expected that establishment of the pest would result in a complete loss of markets. It could however impact on increased costs to manage and inspect for the pest.
Non-commercial and environmental	B – Minor significance at the local level Any additional usage of chemical sprays or changes in biocontrol agents may affect the environment. However, this is unlikely to impact on the environment to any greater extent than already occurs due to control measures for other pests.

4.5.6 Unrestricted risk estimate

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

Unrestricted risk estimate for *Tenuipalpus granati* and *Tenuipalpus punicae*	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

The unrestricted risk estimates for *Tenuipalpus granati* and *Tenuipalpus punicae* are assessed as Low, which do not achieve the ALOP for Australia. Therefore, specific risk management measures are required for these pests on this pathway.

4.6 Western flower thrips, Chilli thrips and Mangosteen thrips

Frankliniella occidentalis (GP, NT, RA), *Scirtothrips dorsalis* (GP, RA) and *Scirtothrips oligochaetus* (GP)

Three thrips species were identified on the pomegranate whole fruit from India pathway that are either quarantine pests or regulated articles for Australia: *Frankliniella occidentalis, Scirtothrips dorsalis* and *Scirtothrips oligochaetus* (Table 4.2). *Frankliniella occidentalis* is not present in Northern Territory; therefore, it is a regional pest for that territory.

Table 4.2 Quarantine and regulated thrips for pomegranate whole fruit from India

Pest	In thrips group PRA	Quarantine thrips	Regulated thrips	On pomegranate whole fruit pathway	Moderate likelihood of entry for thrips verified
Frankliniella occidentalis (GP, NT, RA)	Yes	Yes (NT)	Yes	Yes	Yes
Scirtothrips dorsalis (GP, RA)	Yes	No	Yes	Yes	Yes
Scirtothrips oligochaetus (GP)	Yes	Yes	No	Yes	Yes

GP: Species has been assessed previously in a Group PRA and the Group PRA has been applied. **RA**: regulated article, referred to as 'regulated thrips'. **NT**: Pest of biosecurity concern for the Northern Territory.

The indicative likelihood of entry for all thrips is assessed in the thrips Group PRA as **Moderate**. *Frankliniella occidentalis, Scirtothrips dorsalis* and *Scirtothrips oligochaetus* are reported from India and are associated with pomegranate whole fruit (Balikai, Kotikal & Prasanna 2009; Tyagi & Kumar 2015). Standard packing house procedures and transportation are not expected to eliminate these pests on the pathway. After assessment of the pathway-specific factors (see Section 2.2.7) for the pomegranate whole fruit from India, the likelihoods of entry of Moderate were verified as appropriate for these thrips.

A summary of the risk assessment for quarantine thrips is presented in Table 4.3 for convenience.

Table 4.3 Risk estimates for quarantine thrips

Risk component	Rating for quarantine thrips
Likelihood of entry (importation x distribution)	Moderate (High x Moderate)
Likelihood of establishment	High
Likelihood of spread	High
Overall likelihood of entry, establishment and spread	Moderate
Consequences	Low
Unrestricted risk	**Low**

The indicative unrestricted risk estimate for quarantine thrips, is Low which does not achieve the ALOP for Australia, as assessed in the thrips Group PRA (Table 4.3).

This indicative unrestricted risk estimate is considered to be applicable to quarantine thrips species present on the pomegranate whole fruit from India pathway. Therefore, specific risk management measures are required for quarantine thrips to achieve the ALOP for Australia.

Frankliniella occidentalis and *Scirtothrips dorsalis* are identified as regulated articles, because they are capable of harbouring and spreading (vectoring) emerging tospoviruses that are quarantine pests for Australia, as detailed in the thrips Group PRA (Australian Government Department of Agriculture and Water Resources 2017).

A regulated article is defined by the IPPC as 'Any plant, plant product, storage place, packaging conveyance, container, soil and any other organisms, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved' (FAO 2019b). For simplicity, any thrips identified as a regulated article is referred to as a regulated thrips.

The indicative likelihood of entry for all thrips is assessed in the thrips Group PRA as Moderate. This indicative likelihood is also relevant to regulated thrips that can transmit quarantine tospoviruses. As indicated earlier in this section, the likelihood of entry of Moderate was verified as appropriate for the regulated thrips (Table 4.4).

A summary of the risk assessment for quarantine tospoviruses transmitted by thrips is presented in Table 4.4 for convenience.

Table 4.4 Risk estimates for emerging quarantine tospoviruses vectored by regulated thrips

Risk component	Rating for emerging quarantine tospoviruses (a)
Likelihood of entry (importation x distribution)	Low (Moderate x Moderate)
Likelihood of establishment	Moderate
Likelihood of spread	High
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	**Low**

(a): The identified regulated thrips vectors emerging tospoviruses, and this table presents the risk estimates for these viruses from the thrips Group PRA.

The indicative unrestricted risk estimate for emerging quarantine tospoviruses transmitted by regulated thrips is Low, which does not achieve the ALOP for Australia, as assessed in the thrips Group PRA (Table 4.4).

This indicative unrestricted risk estimate is considered to be applicable to emerging tospoviruses known to be vectored by the thrips species that are present on the pomegranate whole fruit from India pathway. Therefore, specific risk management measures are required for the regulated thrips to mitigate the risks posed by emerging quarantine tospoviruses, in order to achieve the ALOP for Australia.

The conclusion of this risk assessment, which is based on the thrips Group PRA, applies to all phytophagous quarantine thrips and regulated thrips on the pomegranate whole fruit from India, irrespective of their specific inclusion in this document.

4.7 Annona mealybug, Papaya mealybug and Vine mealybug

Dysmicoccus neobrevipes (GP), *Paracoccus marginatus* (GP) and *Planococcus ficus* (GP)

Three mealybug species were identified on the pomegranate whole fruit from India pathway that are quarantine pests for Australia: *Dysmicoccus neobrevipes, Paracoccus marginatus* and *Planococcus ficus* (Table 4.5).

Table 4.5 Quarantine mealybugs for pomegranate whole fruit from India

Pest	In mealybugs group PRA	Quarantine pest	On pomegranate whole fruit pathway	Moderate likelihood of entry verified
Dysmicoccus neobrevipes (GP)	Yes	Yes	Yes	Yes
Paracoccus marginatus (GP)	Yes	Yes	Yes	Yes
Planococcus ficus (GP)	Yes	Yes	Yes	Yes

GP: Species has been assessed previously in a Group PRA and the Group PRA has been applied. **RA:** regulated article, refer to section 4.6 for definition of a regulated article.

The indicative likelihood of entry for all mealybugs is assessed in the mealybug Group PRA as **Moderate** (Australian Government Department of Agriculture and Water Resources 2017). *Dysmicoccus neobrevipes, Paracoccus marginatus* and *Planococcus ficus* are reported to be present in India (Mani, Smitha & Najitha 2016; Muniappan et al. 2008; Suroshe et al. 2016) and are associated with pomegranate whole fruit (Miller et al. 2014; Sakthivel et al. 2012; Suroshe et al. 2016; USDA 2010). Standard packing house procedures and transportation are not expected to eliminate the pests on the pathway. After assessment of the pathway-specific factors (Section 2.2.7) for pomegranate whole fruit from India, likelihood of entry of Moderate were verified as appropriate for these quarantine mealybugs (Table 4.6).

A summary of the risk assessment for quarantine mealybugs is presented in Table 4.6 for convenience.

Table 4.6 Risk estimates for quarantine mealybugs

Risk component	Rating for quarantine mealybugs
Likelihood of entry (importation x distribution)	Moderate (High x Moderate)
Likelihood of establishment	High
Likelihood of spread	High
Overall likelihood of entry, establishment and spread	Moderate
Consequences	Low
Unrestricted risk	**Low**

The indicative unrestricted risk estimate for mealybugs is Low, which does not achieve the ALOP for Australia, as assessed in the mealybugs Group PRA (Table 4.6).

This indicative unrestricted risk estimate is considered to be applicable for the quarantine mealybugs species present on the pomegranate whole fruit from India pathway. Therefore, specific risk management measures are required for the quarantine mealybugs to achieve the ALOP for Australia.

The conclusion of this risk assessment, which is based on the mealybug Group PRA, applies to all other phytophagous quarantine mealybugs on pomegranate whole fruit from India, irrespective of their specific inclusion in this document.

4.8 Honeydew moth

Cryptoblabes gnidiella (EP)

Cryptoblabes gnidiella (honeydew moth) belongs to the family Pyralidae. The Pyralidae or 'snout moths' are one of the largest families of the order Lepidoptera (Common 1990). The structure of their mouthparts gives them a snout-like appearance (Ciesla 2011). Members of this family are mainly distributed in tropical countries (Hill 2008). The larvae feed on a wide variety of materials including dry and decaying plant matter, grains, fruit, leaves, stems and new shoots (Ciesla 2011; Hill 1987, 2008).

The common name for *C. gnidiella*, 'honeydew moth', is derived from the fact that adult moths are attracted to the sweet matter produced in association with host infestation by other insects, including insect honeydew and juices from damaged fruit.

Cryptoblabes gnidiella is known to be present in many countries representing a range of climatic conditions, including in Austria, Bermuda, Brazil, Cyprus, Egypt, France, Greece, India, Israel, Italy, Lebanon, Liberia, Malaysia, Malta, Morocco, New Zealand, Nigeria, Pakistan, Portugal, Sierra Leone, South Africa, Spain, Thailand, Turkey, Uruguay, USA (Hawaii) and Zimbabwe (CABI 2019; EPPO 2019; Speidel 1996).

Cryptoblabes gnidiella is polyphagous and its host range includes about 50 plant species from 30 families. Host plants include mango, pineapple, papaya, beet, persimmon, maize, sorghum, wheat, avocado, cotton, fig, guava, feijoa, carambola, macadamia, pomegranate, apple, apricot, peach, pear, plum, grapefruit, lemon, orange and grape (Yehuda, Wysoki & Rosen 1991).

Pyralid moths have four life stages: egg, larva, pupa and adult. Eggs are laid on host plants on any suitable surface, including on fruit, foliage and grains (Carter 1984; Taley, Dongardeo & Sharnagat 1974). Once the eggs hatch, the larvae frequently feed on the waste produced by other insects (Avidov & Harpaz 1969b; Ioriatti, Lucchi & Varela 2012), as well as on host fruit, seeds, flowers, foliage and stems (Avidov & Gothilf 1960; Dawidowicz & Rozwalka 2016). This species can pupate on the host plant including on fruit as well as in the ground (Avidov & Gothilf 1960; Cocuzza et al. 2016; Dawidowicz & Rozwalka 2016; Singh & Singh 1995). Adults are capable of independent movement and can fly to find a suitable mate and host.

Cryptoblabes gnidiella is reported to be present in India, and not present in Australia; therefore, it is a pest of biosecurity concern for Australia (Singh & Singh 1995). The moth is reported to cause serious damage to hybrid sorghum and pearl millet in India (Singh & Singh 1995), and is a serious pest on pomegranate in Turkey, causing fruit damage (Demirel 2016).

The risk scenario of biosecurity concern for *C. gnidiella* is the potential presence of eggs, larvae and pupae on or in pomegranate whole fruit from India.

Adult *C. gnidiella* moths are considered unlikely to be associated with the pathway of commercially produced pomegranate whole fruit from India, as they are active fliers and likely to be disturbed and detected during packing house processes.

Cryptoblabes gnidiella has previously been assessed for the sweet oranges from Italy pathway (Biosecurity Australia 2005) and found to have an unrestricted risk estimate of Low. The risk assessment presented here builds on this previous assessment.

The likelihood of importation and distribution may be different to the previous assessment of *C. gnidiella* due to differences in commodity, horticultural practices and prevalence of pest species between the export areas previously considered. Therefore, the likelihood of importation and distribution will be reassessed here.

The assessments of likelihoods of establishment and spread will be adopted from the previous assessment of *C. gnidiella*, as these likelihoods relate specifically to post-import events that occur in Australia, are largely independent of the importation pathway, and primarily dependent upon host availability and climatic conditions.

The assessment of potential consequences if the species were to enter, establish and spread in Australia will also be adopted from the previous assessment of *C. gnidiella* as this rating is also independent of the importation pathway.

In making this assessment, the department has reviewed the latest literature about *C. gnidiella* (Chandel, Bhadauriya & Chauhan 2010; Öztürk 2010; Öztürk & Ulusoy 2011a; Öztürk & Ulusoy 2012; Ringenberg et al. 2005; Sellanes & González 2014; Vidart et al. 2013; Yildirim & Başpınar 2015). Identified new information relating to potential control methods and additional host species does not change the risk ratings for establishment, spread or consequences as set out for the sweet oranges from Italy pathway (Biosecurity Australia 2005). Therefore, those risk ratings will be adopted for this pest risk analysis.

4.8.1 Likelihood of entry

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

Likelihood of importation

The likelihood that *C. gnidiella* will arrive in Australia with the importation of pomegranate whole fruit from India is assessed as: **Low**.

The following information provides supporting evidence for this assessment.

- *Cryptoblabes gnidiella* is a secondary pest of pomegranate (Cocuzza et al. 2016), associated with whole fruit infested by scale insects, mealybugs and other insect pests such as *Deudorix isocrates* (Avidov & Harpaz 1969b). Ovipositing females are particularly attracted to sweet substances, including honeydew produced by other arthropod pests on pomegranate fruit (Cocuzza et al. 2016).
- *Cryptoblabes gnidiella* is reported to be a serious pest on sorghum and millet, causing losses to production in areas where pomegranate is grown in India (Singh & Singh 1995). While there is limited literature to suggest that this moth is a pest of pomegranate in India, there is a possibility that the pest may occur in pomegranate orchards.
- Adult females of *C. gnidiella* are known to lay eggs on pomegranate plants, including on damaged fruit and in the fruit calyx in other countries (Blumenfeld, Shaya & Hillel 2000; Öztürk 2018). Moth-infested fruit are likely to have already been infested (as a primary infestation) by other pests, and are likely to be detected during packing house practices for export. Therefore, commercially produced, export quality pomegranate whole fruit is considered unlikely to provide a pathway for this pest.

- Under laboratory conditions, *C. gnidiella* has been shown to lay up to 230 eggs over its lifetime (Wysoki, Yehuda & Rosen 1993). Eggs of *C. gnidiella* are creamy-white with an average size of 0.45mm x 0.32mm (Singh & Singh 1995) and the incubation period averages from three to seven days (Carter 1984; Taley, Dongardeo & Sharnagat 1974).
- Standard packing house procedures for cleaning and washing pomegranate whole fruit are likely to remove *C. gnidiella* eggs from the external surface of fruit. However, eggs laid in the calyx are less likely to be removed.
- Larvae cause damage to pomegranate fruit. *Cryptoblabes gnidiella* larvae develop through five instars with the larval period averaging 13.9 days on pomegranate (Öztürk & Ulusoy 2011b). Larvae are brown and cylindrical in shape; first instar larvae range in size from 1.52mm to 1.58mm long and 0.33mm to 0.35mm wide, and final instar larvae range from 11.76mm to 12.03mm long and 1.94mm to 2.09mm wide (Bhadauriya, Chauhan & Chandel 2011).
- Larvae and pupae of *Cryptoblabes gnidiella* were reported to be found on imported pomegranate fruit in retail stores in Poland (Dawidowicz & Rozwalka 2016). The authors collected fruit with visible traces of feeding, which was on the remnants of corollas, suggesting that the infestation was primarily external. The report noted however that the larvae of *C. gnidiella* do not feed on the consumable part of the fruit (i.e. arils).
- While there is no available literature suggesting that *C. gnidiella* larvae bore into healthy pomegranate fruit through the rind, larvae of *C. gnidiella* have been found inside pomegranate fruit (Guario 2018), likely due to movement through the calyx or sites of damage on the fruit caused by primary infestation by other pests.
- Pomegranate fruit infested by *C. gnidiella* larvae are susceptible to crown rot which develops as the fruit matures or during storage (Blumenfeld, Shaya & Hillel 2000); therefore, infested fruit are likely to be detected prior to export.
- *Cryptoblabes gnidiella* can pupate on the host plant, in fruit or in the soil (Cocuzza et al. 2016; Dawidowicz & Rozwalka 2016; Singh & Singh 1995). The pupal period averages 6.9 days on pomegranate (Öztürk & Ulusoy 2011b). Pupae are dark brown and range in size from 6.80mm to 7.22mm long and 1.89mm to 2.02mm wide (Bhadauriya, Chauhan & Chandel 2011; Dawidowicz & Rozwalka 2016; Singh & Singh 1995; Taley, Dongardeo & Sharnagat 1974). Due to their colour and size, pupae of *C. gnidiella* on the fruit surface are likely to be detected prior to export. However, pupae inside the fruit may go undetected.
- *Cryptoblabes gnidiella* has been reported to overwinter as larvae or pupae (Carter 1984; Singh & Singh 1995; Yehuda, Wysoki & Rosen 1991); therefore, larvae and pupae are likely to survive storage and transport of pomegranate whole fruit at the proposed temperature of 5°C to 8°C.

Cryptoblabes gnidiella is associated with pomegranate in India. The moth is reported to be a secondary pest of pomegranate in other countries, and infests fruit that are already damaged by other pests. It has high fecundity and lays small eggs on fruit and in the fruit calyx. Larvae cause damage that is visible. Infested fruit are likely to be detected due to other damage. Some life stages present on the surface of fruit would also be removed by packing house processes. Larvae and pupae would likely survive storage and transport. These factors collectively support a likelihood estimate for importation of ‘Low’.

Likelihood of distribution

The likelihood that *C. gnidiella* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of pomegranate from India, and subsequently transfer to a susceptible host is assessed as: **Low**.

The following information provides supporting evidence for this assessment.

- Pomegranate whole fruit would be distributed for sale to various destinations in Australia, predominantly to the larger population centres. They may be distributed through large fresh produce wholesale markets and then to supermarkets or other sellers, or directly to smaller retailers and then to consumers.
- *Cryptoblabes gnidiella* has been reported to overwinter as larvae or pupae (Carter 1984; Singh & Singh 1995; Yehuda, Wysoki & Rosen 1991). It is likely that eggs, larvae and pupae would survive storage and transport at the proposed 5°C to 8°C.
- Pomegranates have a thick leathery rind, and arils need to be extracted for consumption. Pomegranate waste, primarily as the leathery rind and mesocarp, is likely to be disposed of as municipal waste, where the waste is likely to desiccate or decay quickly, and from where it is unlikely that larvae and pupae will survive. However, some pomegranate waste disposed of as litter may reach urban, peri-urban and/or agricultural environments.
- Larvae found in dry pomegranate fruit collected from the field have been reported to be reared to maturity on the same fruit in glass jars under indoor and outdoor conditions (Yehuda, Wysoki & Rosen 1991).
- The previous assessment of *C. gnidiella* on the sweet oranges from Italy pathway determined that early instar larvae would be unlikely to develop in discarded sweet orange before the fruit desiccated or decayed (Biosecurity Australia 2005). The condition of discarded pomegranate is also expected to deteriorate quickly in the environment.
- In the event of adults emerging from later-instar larvae or pupae in fruit waste, adult moths could enter the environment. With a broad range of host plants widely distributed across Australia, mated female moths may find a host.

Pomegranate whole fruit will be distributed across Australia and it is possible that eggs, larvae and pupae may survive pomegranate fruit storage and transport. The pest has a broad range of hosts, widely distributed across Australia. Pomegranate fruit waste is likely to be disposed of in waste management systems, but some may be discarded in the environment. Fruit waste is likely to desiccate or decay quickly. If fruit waste was to be infested, these factors would minimise the likelihood of the pest completing its development. These factors support a likelihood estimate for distribution of ‘Low’.

Overall likelihood of entry

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

The likelihood that *C. gnidiella* will enter Australia as a result of trade in pomegranate from India, and be distributed in a viable state to a susceptible host, is assessed as: **Very Low**.

4.8.2 Likelihood of establishment and spread

The likelihoods of establishment and of spread for *C. gnidiella* are similar to those assessed in the pest risk analysis for the sweet oranges from Italy pathway (Biosecurity Australia 2005). The ratings from previous assessments are:

Likelihood of establishment: **High**

Likelihood of spread: **High**

4.8.3 Overall likelihood of entry, establishment and spread

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

The likelihood that *C. gnidiella* will enter Australia as a result of trade in pomegranate from India, be distributed in a viable state to a susceptible host, establish in Australia, and subsequently spread within Australia is assessed as: **Very Low**.

4.8.4 Consequences

It is considered that the consequences of entry, establishment and spread of *C. gnidiella* in Australia are independent of the import pathway, and therefore similar to those provided in the previous pest risk assessment for *C. gnidiella* for the sweet oranges from Italy pathway (Biosecurity Australia 2005). The rating for overall consequences from this previous assessment is 'Moderate'. Therefore, the overall consequences for *C. gnidiella* from the pomegranate whole fruit from India pathway is also assessed as: **Moderate**.

4.8.5 Unrestricted risk estimate

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

Unrestricted risk estimate for *Cryptoblabes gnidiella*	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Moderate
Unrestricted risk	Very Low

The unrestricted risk estimate for *C. gnidiella* on the pomegranate from India pathway is assessed as 'Very Low', which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for this pest on this pathway.

4.9 Bacterial blight of pomegranate

***Xanthomonas axonopodis* pv. *punicae* (Hingorani & Singh) Dye**

Bacterial blight caused by *Xanthomonas axonopodis* pv. *punicae* is a serious threat to pomegranate cultivation as the disease significantly reduces yield, and infected fruits are unmarketable.

Xanthomonas axonopodis pv. *punicae* was first reported affecting pomegranate from Rajasthan in 1952 (Hingorani & Mehta 1952), and since then the pathogen has been reported from Pakistan (Akhtar & Bhatti 1992), South Africa (Petersen et al. 2010a) and Turkey (Icoz et al. 2014). In India, *X. axonopodis* pv. *punicae* is reported from Andhra Pradesh, Haryana, Himachal Pradesh, Karnataka, Maharashtra, Tamil Nadu, Telangana and Rajasthan (Government of India 2017a; Sharma et al. 2017). *Xanthomonas axonopodis* pv. *punicae* is not present in Australia and is therefore a pathogen of biosecurity concern for all of Australia.

Xanthomonas axonopodis pv. *punicae* is a common pathogen in pomegranate orchards in India, with varying prevalence and severity (Sharma et al. 2017); prevalence is the percent of the orchards showing blight infections, and severity is the extent of damage to the fruit caused by the bacterium. Sharma, Sharma and Jadhav (2010) reported a prevalence of 52% in orchards in Maharashtra, of which 13% of orchards had severe blight, 15% moderate blight and 25% mild blight. Blight prevalence in Karnataka was 58% orchards, of which 28% had moderate disease while 33% had mild blight. Andhra Pradesh was reported to have 43% prevalence, of which 17% severe, 22% moderate and 4% mild blight. Disease severity in summer crops is high in Karnataka when fruit development and fruit maturity stages coincide with favourable conditions for the pest, such as higher rainfall and temperature (Yenjerappa, Nargund & Jawadagi 2011).

Xanthomonas axonopodis pv. *punicae* infects all plant parts, but is most destructive on fruits. Obvious symptoms develop on the fruit, but are restricted to the rind (Sharma et al. 2017). Water-soaked lesions that initially appear on the fruit surface later turn dark brown, and enlarge and coalesce to cover large areas. Thin, shiny white encrustations of dried bacterial ooze, or droplets of glue-like bacterial ooze, often appear on lesions. Under conditions of high humidity, blight lesions become sticky or slimy. Small cracks appear on the spots and in severe cases the entire fruit splits open along the lesions, severely reducing the quality of fruits (Munhuweyi et al. 2016; Sharma et al. 2017).

The risk scenario of biosecurity concern for *X. axonopodis* pv. *punicae* is the potential importation of pomegranate whole fruit with early stage infections from India.

4.9.1 Likelihood of entry

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

Likelihood of importation

The likelihood that *X. axonopodis* pv. *punicae* will arrive in Australia with the importation of pomegranate whole fruit from India is assessed as: **Moderate.**

The following information provides supporting evidence for this assessment.

- *Xanthomonas axonopodis* pv. *punicae* is associated with the fruit pathway (Munhuweyi et al. 2016; Sharma et al. 2017) and is present in pomegranate growing areas of India (Government of India 2017a; Sharma et al. 2017).
- Infected fruit are notably symptomatic, showing dark brown necrotic lesions, cracks and splitting of the entire fruit (Janse 2012b; Munhuweyi et al. 2016). *Xanthomonas axonopodis* pv. *punicae* can infect pomegranate fruit any time during its development through natural openings, even in the absence of injuries (Sharma et al. 2017). However, the highest levels of disease severity are reported to coincide with developing and fruit maturing stages (Yenjerappa, Nargund & Jawadagi 2011), suggesting that these stages may be the most receptive to infection. Bacterial blight symptoms generally appear within one to two weeks of infection (Sharma et al. 2010).
- Symptomatic fruits are not marketable, and are likely to be discarded during packing house processes; therefore, fruits with obvious external symptoms are unlikely to be imported. However, mature fruits infected through natural openings just prior to harvest may not have developed visible external symptoms. It is possible that fruits with early stages of infection could be exported to Australia.
- *Xanthomonas axonopodis* pv*. punicae* infections establish within the rind (Janse 2012b; Munhuweyi et al. 2016), and are unlikely to be eliminated during standard harvesting, handling and shipping operations.
- *Xanthomonas axonopodis* pv. *punicae* is likely to survive storage and transport. Pomegranate whole fruit are anticipated to be shipped in refrigerated containers maintained at 5°C to 8°C; these conditions are unlikely to adversely affect *X. axonopodis pv. punicae*, which is reported to overwinter in infected leaves of neem and bael planted on the boundaries of pomegranate orchards (Kumar et al. 2009). The development threshold temperature of *X. axonopodis pv. punicae* is between 5°C to 8°C (Hingorani & Mehta 1952; Manjula & Khan 2003); therefore, bacterium may continue to multiply at low levels during cold storage and transport.
- Packing house processes, particularly washing with clean water and sanitising with disinfectants such as Tsunami™ or hypochlorite may remove some of the infection, especially the initial colonisation on the surface of the rind; however, it is less likely to completely eliminate any infection that has spread underneath the rind surface.

Xanthomonas axonopodis pv. *punicae* is present in India and reported to cause damage to pomegranates. Infection with the bacterium causes severe symptoms on developing and maturing fruit, which become evident in a relatively short—one to two week—period. Well-developed symptoms are external and visible, and are likely to be detected during packing house processes; such fruit will be excluded from export. Washing with clean water and sanitising with disinfectant may minimise the survival of the bacterium on the fruit. However, early stages of infection with no visible symptoms are unlikely to be detected through packing house practices, potentially allowing the bacterium to be imported into Australia. These factors support a likelihood estimate for importation of 'Moderate'.

Likelihood of distribution

The likelihood that *X. axonopodis* pv. *punicae* will be distributed in a viable state within Australia with imported pomegranate whole fruit from India and transferred to a suitable host is assessed as: **Low.**

The following information provides supporting evidence for this assessment:

- It is likely that *X. axonopodis* pv. *punicae* will arrive on infected pomegranate whole fruit in a viable state, as the bacterium is able to survive in infected fruit for up to five months (Yenjerappa, Nargund & Jawadagi 2011; Yenjerappa 2009), and tolerate temperatures which the fruit will be transported (Hingorani & Mehta 1952; Manjula & Khan 2003).
- Pomegranate whole fruit would be distributed for sale to various destinations in Australia. They may be distributed through large fresh produce wholesale markets and then to supermarkets or other sellers, or directly to smaller retailers and then to consumers. Distribution of infected fruit would facilitate the distribution of *X. axonopodis* pv*. punicae*.
- Pomegranate is the major host of *X. axonopodis* pv. *punicae*. The bacterium was also reported on *Azadirachta indica* (neem) and *Aegle marmelos* (bael) (Hingorani & Mehta 1952; Kumar et al. 2006); however, damage caused by the bacterium on these hosts is not widely reported, suggesting they may not be as significant hosts as pomegranate. Neem and Bael plants are not widespread in Australia and are largely limited to the northern parts of the continent.
- The intended end use of commercially produced pomegranate whole fruit for consumption will also limit the likelihood of *X. axonopodis* pv. *punicae* transferring to a suitable host.
- Pomegranate fruit has a thick leathery rind and arils need to be extracted for consumption. Any infected pomegranate waste is likely to be disposed of as municipal waste , from where it is unlikely to distribute *X. axonopodis* pv*. punicae* into the environment.
- Pomegranate waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetation. *Xanthomonas axonopodis* pv. *punicae* is known to be able to survive in infected fruit for about five months (Yenjerappa, Nargund & Jawadagi 2011) and in soil for around 120 days (Kumar et al. 2018).
- A relatively small quantity of fruit waste may be discarded as unmanaged waste. For transmission of this bacterium to a susceptible host to occur, unmanaged waste would need to be placed in close proximity to a suitable host, the bacterium would need to survive on the waste, and environmental conditions would need to be conducive for infection.
- Pomegranate seed discarded as waste is not a pathway for the distribution of *X. axonopodis* pv. *punicae*, as the bacterium is reported to infect only the rind of fruit, not seeds (Sharma et al. 2017).
- The likelihood of transfer of *X. axonopodis* pv. *punicae* to a suitable host depends on the dispersal mechanisms of this bacterium. Independent dispersal of this bacterium from fruit to the environment requires high humidity for the production of a bacterial ooze, which contains bacterial cells (Sharma, Pandey & Shankar 2012). The movement of bacterial cells to a suitable host may occur through rain splash (Munhuweyi et al. 2016; Sharma, Sharma & Jadhav 2010). However, it is unlikely that fruit imported for consumption would be regularly exposed to such conditions in either retail or household environments.

Xanthomonas axonopodis pv. *punicae* could enter Australia in a viable state and be distributed throughout Australia. However, the bacterium would need to survive on waste, produce bacterial cells under suitable climatic conditions, and be transferred to a suitable susceptible host to initiate infection. The intended end use of consumption in a household environment will provide a low likelihood for suitable conditions for the production of bacterial ooze or transfer cells to another host. *Xanthomonas axonopodis* pv. *punicae* is capable of surviving in soil and infected fruit for an extended period; however, its restricted host range and reliance on rain splash for dispersal is likely to limit the transfer of this bacterium to another host. These factors support a likelihood estimate for distribution of 'Low'.

Overall likelihood of entry

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

The likelihood that *X. axonopodis* pv. *punicae* will enter Australia as a result of trade in pomegranate whole fruit from India and be distributed in a viable state to a susceptible host is assessed as: **Low**.

4.9.2 Likelihood of establishment

The likelihood that *X. axonopodis* pv. *punicae* will establish within Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- Pomegranate is the major host of *X. axonopodis* pv. *punicae*. The bacterium has also been reported on *Azadirachta indica* (neem) and *Aegle marmelos* (bael) (Hingorani & Mehta 1952; Kumar et al. 2006); which are not widespread in Australia and largely limited to the northern part of the continent.
- Pomegranate is grown as a fruit tree and an ornamental garden shrub in Australian households (RIRDC 2014). Commercial pomegranate production in Australia was about 500 hectares in 2014. Pomegranate orchards have been established in the Murray–Darling Basin, and in Western Australia, near Carnarvon and south of Perth (AgriFutures Australia 2017b). Therefore, suitable hosts are present in various parts of Australia. However, pomegranate is a deciduous tree, which typically does not retain leaves during winter in temperate parts of Australia to support infection.
- Humid tropical and subtropical environments are most suitable for the establishment of the bacterium (Sharma et al. 2017). However, the pathogen has also been reported to cause crop loss in Western Cape province of South Africa (Petersen et al. 2010b) which has predominantly a Mediterranean climate similar to parts of south-eastern Australia (Riverina, Murray Valley and Riverland) and south-western Western Australia (Bureau of Meteorology 2018).
- *Xanthomonas axonopodis pv. punicae* can survive a wide range of temperatures and humidities; however, infection in India becomes severe under conditions of high humidity (greater than 50%) and moderate temperatures (25°C to 35°C) during the rainy season (Bhange & Hingoliwala 2015; Munhuweyi et al. 2016). Stormy weather causes epidemic outbreaks (Sharma, Sharma & Jadhav 2010).
- *Xanthomonas axonopodis* pv. *punicae* has a robust reproductive strategy for establishment, including the ability to infect through natural plant openings.

- *Xanthomonas axonopodis* pv. *punicae* remains viable in the margins of lesions on leaves and fruit. The bacterium can survive on fallen leaves for extended periods; the bacterium was reported to survive more than eight months on infected leaves kept under field conditions, and up to seven months at room temperature (Hingorani & Singh 1959; Rani & Verma 2002). In addition, *X. axonopodis* pv. *punicae* can survive in cankers on intact branches for more than six months (Rani & Verma 2002). During suitable conditions, the bacterium will produce bacterial cells to initiate fresh infections on new growth.

Xanthomonas axonopodis pv*. punicae* has hosts available in Australia, climatic conditions in parts of Australia are suitable for its reproduction, and the bacterium is reported to withstand relatively harsh conditions in infected host plant material. However, establishment requires the pathogen to have suitable climatic conditions, including high humidity, rainfall and favourable temperature that are not common throughout the year in areas where the major host, pomegranate, is grown in Australia, potentially limiting the pathogen's ability to establish. These factors support a likelihood estimate for establishment of 'Moderate'.

4.9.3 Likelihood of spread

The likelihood that *X. axonopodis* pv. *punicae* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- Natural climatic conditions, including in parts of pomegranate growing areas in Australia, are potentially favourable for the spread of the bacterium.
- *Xanthomonas axonopodis* pv. *punicae* has effective dispersal strategies. The bacterium readily spreads over short distances via rain splash and over long distances within orchards by mechanical means such as contaminated pruning tools within orchards (Sharma, Sharma & Jadhav 2010).
- The presence of natural geographic barriers in Australia may limit the spread *of X. axonopodis* pv. *punicae*. Natural barriers such as arid areas, mountain ranges, climatic differentials and possible long distances between suitable hosts may prevent long-range natural spread of this bacterium. However, the occurrence of this bacterium in all major pomegranate-growing states of India suggests that the pest has the potential to spread across areas with varying environmental and climatic conditions. Nevertheless, the Australian pomegranate industry is located across Australia in isolated regions with long distances often separating commercial orchards. This may limit long-range natural spread of this bacterium.
- Pomegranate is, however, becoming a common household plant. It is grown as a fruit tree and an ornamental garden shrub in Australian households (RIRDC 2014).
- There is potential for the movement of this bacterium with commodities. Human-mediated movement of infected propagative material is considered to be the primary mode for the introduction and spread of plant pathogens into new areas. Spread via human-mediated means could be rapid and cover long distances. However, interstate biosecurity controls on the movement of nursery stock and horticulture commodities in Australia may reduce the likelihood of interstate spread of the pathogen.

- *Xanthomonas axonopodis* pv. *punicae* is not known to have natural enemies that could hamper its spread. *Bacillus subtilis, Pseudomonas fluorescens, P. aeruginosa* and *Lactobacillus* species have been tested but found not to be effective for controlling the spread of this bacterium (Chavan et al. 2016; Manjula & Khan 2003; Yenjerappa, Nargund & Jawadagi 2011).

Xanthomonas axonopodis pv. *punicae* has natural and managed environments in Australia suitable for its spread. While the pest disperses primarily via rain splash over short distances, human-mediated movement of propagative material and infected fruit could aid its long-distance dispersal; this may be mitigated to some extent through interstate biosecurity controls on the movement of nursery stock and horticulture commodities. Natural barriers in Australia could limit the spread of *X. axomnopodis* pv. *punicae*. Pomegranate, although not common, is grown as a fruit tree and ornamental shrub in home gardens; however, pomegranate orchards are relatively isolated and limited in distribution. The bacterium has no known natural enemies that may limit its spread. These factors collectively support a likelihood estimate for spread of 'Moderate'.

4.9.4 Overall likelihood of entry, establishment and spread

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

The overall likelihood that *X. axonopodis* pv. *punicae* will enter Australia as a result of trade in pomegranate whole fruit from India, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is assessed as: **Low**.

4.9.5 Consequences

The potential consequences of the establishment of *X. axonopodis* pv. *punicae* in Australia have been estimated according to the methods described in Table 2.3.

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

Criterion	Estimate and rationale
Direct	
Plant life or health	E – Major significance at the district level Bacterial blight caused by *X. axonopodis* pv. *punicae* is a main limiting factor for major pomegranate producers in the world such as India, Pakistan, South Africa and Turkey (AgriFutures Australia 2017b). Yield losses of 60% to 100% have been reported from India (Kumar et al. 2018; Lalithya et al. 2017). If established, *X. axonopodis* pv. *punicae* could be expected to cause significant losses to pomegranate crops in Australia. Pomegranate is grown as a fruit tree and an ornamental garden shrub in Australian households (RIRDC 2014). The commercial pomegranate industry is small in Australia; however, is expected to expand (RIRDC 2008). In 2014, there were about 500 hectares of commercial pomegranate orchards in Australia producing about 4,000 tonnes a year. There are a number of smaller orchards growing pomegranates for the whole fresh and 'ready-to-eat' arils market (AgriFutures Australia 2017b). *Xanthomonas axonopodis* pv. *punicae* prefers warm, rainy and humid environments for infection. However, the pathogen has been reported to cause pomegranate crop loss in the Western Cape province of South Africa (Petersen et al. 2010b) which has

	predominantly a Mediterranean climate similar to parts of south-eastern Australia (Riverina, Murray Valley and Riverland) and south-western Western Australia (Bureau of Meteorology 2018). Major pomegranate production areas in Australia occur in south-eastern Australia (AgriFutures Australia 2017b).
Other aspects of the environment	A – Indiscernible at the local level No impact of the pathogen has been reported on the environment. *Xanthomonas axonopodis* pv. *punicae* has a narrow natural host range with evidence suggesting that the pest would not infect a wide range of hosts including many horticultural crops (Ashish & Arora 2016).
Indirect	
Eradication, control	D – Significant at the district level It is expected that efforts would be taken to contain and possibly eradicate an incursion of *X. axonopodis* pv. *punicae* within Australia. The economic viability of production would be threatened through increases in costs for containment, eradication and control at the district level. Bacterial blight is managed by applying systemic and non-systemic pesticides together with antibiotics (Jadhav & Sharma 2011; Kumar et al. 2018), plant growth regulators (Lalithya et al. 2017), cultural methods such as pruning (Yenjerappa, Nargund & Jawadagi 2011) and nutrient management (Maity et al. 2018). Any action, particularly chemical control in response to a *X. axonopodis* pv. *punicae* incursion would be costly and could cause disruption to agribusiness and associated trade within the affected area.
Domestic trade	D – Significant at the district level If *Xanthomonas axonopodis* pv. *punicae* was to establish in Australia, it would be expected to result in domestic movement restrictions on pomegranate fruit. The Australian pomegranate industry is focused on the domestic market and small-scale producers sell fruits to retailers or in local markets (AgriFutures Australia 2017b). Compliance with domestic biosecurity requirements would impose additional costs for producers, rendering part of existing and/or future interstate trade uneconomic. Given that the spread of the bacterium between regions occurs through infected planting material, restrictions on movement and trade of pomegranate planting material between production areas may be required.
International trade	D – Significant at the district level *Xanthomonas axonopodis* pv. *punicae* is considered of quarantine significance by the USA (USDA 2018). *Xanthomonas axonopodis* pv. *punicae* is currently regulated by Australia's trading partners on pomegranate nursery stock exports (Department of Agriculture and Water Resources 2018b). Australia currently has export market access for pomegranate fruit to Fiji, Indonesia, Nauru, Papua New Guinea, Qatar, Singapore, Tonga and United Arab Emirates. If this bacterium were to establish, trading partners may review their phytosanitary requirements for affected commodities. This may threaten economic viability.
Non-commercial and environmental	A – Indiscernible at the local level There are currently no known direct consequences of *X. axonopodis* pv. *punicae* on the environment. Chemical application to control the disease could affect the environment, but it is not expected to have any greater effect than the present use of agrochemicals. Indirect effects on native plants from pesticide applications are also expected to have indiscernible consequences.

4.9.6 Unrestricted risk estimate

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

Unrestricted risk estimate for *Xanthomonas axonopodis* pv. *Punicae*	
Overall likelihood of entry, establishment and spread	Low
Consequences	Moderate
Unrestricted risk	Low

As indicated, the unrestricted risk for *X. axonopodis* pv. *punicae* has been assessed as ‘Low’, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for *X. axonopodis* pv. *punicae* on this pathway.

4.10 Cercospora fruit spot/blotch

Pseudocercospora punicae **(Henn.) Deighton**

Pseudocercospora punicae (Synonym: *Cercospora punicae*) infects leaves and fruits of pomegranate causing leaf blotch and fruit spots (Bakhshi et al. 2014; Farr & Rossman 2019; Nakashima et al. 2016). The current geographic distribution of *P. punicae* indicates that the pathogen is well established in humid tropical and subtropical environments (Bakhshi et al. 2014; Farr & Rossman 2019; Leung, Goh & Hyde 1997; Phengsintham et al. 2011). Fruit spot caused by *P. punicae* has been reported on pomegranate with varying degrees of severity in different areas of India (ICAR 2017; Khosla & Bhardwaj 2013; Kumari 2017; Samuel 1995).

Pseudocercospora punicae is not known to occur in Australia and is therefore a pathogen of biosecurity concern for all of Australia.

Pomegranate fruit infected by *P. punicae* initially show small, circular brown spots which later coalesce into larger spots (up to 12mm), discolouring a considerable proportion of the fruit surface (Patil & Patil 2014; Wolf 1927). In severe infections, the fruit cracks, reducing the fruit yield and market value (Archana 2012; Khosla & Bhardwaj 2013). The fungus also causes severe leaf spot and defoliation of pomegranate plants (Kobayashi & Kawabe 1992; Wolf 1927). Black, elliptical spots appear on twigs, causing them to desiccate, and in severe cases the fungus kills the whole plant (Patil & Patil 2014; Reddy 2010).

There is limited information available on the disease cycle of *P. punicae* (Mukesh 2018). As a result, where appropriate, this risk assessment has considered comparable fruit and leaf-spot diseases caused by other *Cercospora* species on horticultural crops.

Higher levels of *Cercospora* leaf and fruit spot severity are reported in warm (20°C to 30°C), humid (84% relative humidity or above) and rainy conditions (Phengsintham et al. 2011; Samuel 1995). Large numbers of spores are produced and higher rates of germination of spores are reported under these conditions (Pohronezny, Simone & Kotze 1994). Leaf lesions are considered the main source of inoculum for the spread of the pathogen (Wolf 1927). Movement of *Cercospora* spores to a suitable host can occur through wind, rain splash or insects (Pohronezny, Simone & Kotze 1994). Human-assisted long-distance spread occurs mainly through infected propagative material (Pohronezny, Simone & Kotze 1994).

Entry of a host by *P. punicae* is expected to occur either through stomata or through wounds, similar to *Cercospora* species (Pohronezny, Simone & Kotze 1994; Solheim 1930). Under optimal conditions, *Pseudocercospora* species develop very quickly and symptoms appear on leaves in as few as five to 10 days after infection (Pohronezny, Simone & Kotze 1994; Solheim 1930). *Pseudocercospora punicae* is reported to survive in infected leaves and fruit debris for up to five months, forming thick-walled resting structures (Samuel 1995). Cells in these structures reanimate during warm rainy weather giving rise to a large number of infectious spores which initiate infections (Pohronezny, Simone & Kotze 1994).

The natural host range of *P. punicae* is considered to be restricted to pomegranate (Bakhshi et al. 2014; Nakashima et al. 2016). *Pyracantha angustifolia*, *P. coccinea, P. crenatoserrata* and *P. crenulata* were reported to be hosts of *P. punicae* by Kobayashi (2007) in Japan (Farr & Rossman 2020), but there are no additional reports of the occurrence of *P. punicae* on

Pyracantha species (Bakhshi et al. 2014). Therefore, *Pyracantha* species have not been considered as potential hosts of the fungus in this assessment.

The risk scenario of biosecurity concern for *P. punicae* is that the fungus and spores may be present on pomegranate whole fruit as early infections which are difficult to detect, and may be imported into Australia.

4.10.1 Likelihood of entry

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

Likelihood of importation

The likelihood that *P. punicae* will arrive in Australia with the importation of pomegranate whole fruit from India is assessed as: **Low**.

The following information provides supporting evidence for this assessment.

- *Pseudocercospora punicae* is endemic to India (Bakhshi et al. 2014; Farr & Rossman 2019; Leung, Goh & Hyde 1997; Phengsintham et al. 2011). *Cercospora* fruit spot incidence has been reported to vary with incidences of up to 32% in Maharashtra, 1.1% to 17.3% in Himachal Pradesh and 1% to 2% in Karnataka (ICAR 2017; Khosla & Bhardwaj 2013; Kumari 2017; Samuel 1995).
- While *Pseudocercospora* fruit spot has been reported across a number of pomegranate producing states in India, the disease incidence is lower than those of some other fungal diseases such as scab (ICAR 2012), anthracnose and *Alternaria* rot (Benagi et al. 2011). In addition, various chemical and cultural methods have been reported to achieve a high level of control of the pathogen (ICAR 2017; Kumari 2017; Patil & Patil 2014).
- *Pseudocercospora punicae* infects all stages of pomegranate fruit from flowering to ripening stages (Wolf 1927). Initial inoculum generally comes from infected leaves (Wolf 1927) and inoculum may be available throughout the year as pomegranate plants in India retain some of their foliage throughout the year.
- Obvious external symptoms on the fruit initially appear as small brown spots, later coalescing into dark brown to black spots/blotches of 1mm to 12mm, and are normally confined to the rind. In severe cases, the fruit cracks (Archana 2012; Patil & Patil 2014; Phengsintham et al. 2011; Wolf 1927). Pale brown spores are produced over the fruit blotches giving a velvety appearance (Bakhshi et al. 2014). Symptomatic fruits are not marketable, and are therefore unlikely to be harvested, packed and exported.
- There is no information on how long the pathogen takes to show symptoms on infected fruit. Artificial infection of wounded pomegranate leaves with conidial suspensions took seven days to show symptoms (Samuel 1995), conidial inoculation of healthy leaves was reported to take 14 days, and mycelial inoculation took 27 days to exhibit symptoms under experimental conditions (Mukesh 2018). Based on this, it may be possible that pomegranate whole fruit with visually undetectable infection could be imported into Australia.

- Packing house processes, including cleaning and sanitation are likely to minimise the risk of the pathogen being present on the fruit; however, these are unlikely to completely eliminate the fungus from infected fruit.
- Fruit is typically stored and transported in refrigerated containers maintained at 5°C to 8°C. While there is no literature available on reported temperature threshold for *P. punicae*, some *Cercospora* species were reported to have a very slow growth rate at 5°C (Vereijssen 2004), suggesting that transport and storage conditions are unlikely to be lethal to the pathogen.

Pseudocercospora punicae is widespread in pomegranate production areas in India and is known to infect pomegranate fruit. However, *Pseudocercospora* incidence is lower than some other diseases of pomegranate. Mature fruit infected just prior to harvest, with no visually detectable symptoms, may be packed for export, and the pathogen could survive cold storage and transport conditions. However, infected fruit that show obvious external symptoms are likely to be detected and removed from the pathway prior to export. Other packing house processes are likely to further minimise the presence of the fungus on the fruit. These factors support a likelihood estimate for importation of 'Low'.

Likelihood of distribution

The likelihood that *P. punicae* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of pomegranate from India and subsequently transfer to a susceptible part of a host is assessed as: **Low**.

- Imported pomegranate fruit would be distributed for sale to various destinations in Australia, predominantly to the larger population centres. They may be distributed through large fresh produce wholesale markets and then to supermarkets or other sellers, or directly to smaller retailers, and thence to consumers. Distribution of infected fruit would facilitate the distribution of *P. punicae*.
- Pomegranates have a thick leathery rind and arils need to be extracted for consumption. Any infested pomegranate waste is likely to be disposed of as municipal waste, from where it is unlikely to distribute *P. punicae* into the environment. However, pomegranate waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetation.
- For transmission to a susceptible host to occur, unmanaged waste would need to be placed in close proximity to a suitable host, the fungus would need to survive on waste, and environmental conditions would need to be conducive for spore production and infection.
- In general, survival of a pathogen in unmanaged fruit waste is expected to be of short duration due to dehydration and competition from other organisms.
- *Psuedocercospora punicae* is reported to survive in infected, fallen leaves and fruits for up to five months (Samuel 1995).
- Pomegranate from India will be imported throughout the year. However, *P. punicae* would only be transferred from waste material to a suitable host in Australia when conditions are conducive for sporulation, dispersal and infection.

- During warm (24°C to 28°C) and wet weather, large numbers of infectious, conidial spores can be produced and spread to a suitable host through wind, rain splash, or with sprinkler irrigation water (Pohronezny, Simone & Kotze 1994).
- The natural host range of *P. punicae* is restricted to pomegranate. *Pyracantha angustifolia, P. coccinea, P. crenatoserrata* and *P. crenulata* were reported as hosts of *P. punicae* by Kobayashi (2007) in Japan (Farr & Rossman 2020), but there are no additional reports on the occurrence of *P. punicae* on *Pyracantha* spp. or other evidence of a host-pathogen relationship (Bakshi et al. 2014). Therefore, *Pyracantha* spp. have not been considered as potential hosts of the fungus in this assessment.
- Pomegranate plants need to be in a susceptible state for infection to occur (i.e. when the plants are actively growing, and new growth of pomegranate leaves and fruits is available), and be in close proximity for fungal spores to reach host plant parts. However, pomegranate is a deciduous tree, which typically does not retain leaves during winter in temperate parts of Australia, limiting the availability of the only horticultural host.
- Pomegranate seed is not a recognised pathway for distribution of *P. punicae* as the fungus is not known to be seed-borne.

The distribution of infected fruit would facilitate the distribution of *P. punicae* throughout Australia. The majority of fruit waste or affected fruits would be discarded through managed waste systems that are unlikely to provide a viable transmission pathway to a suitable host. *Pseudocercospora punicae* could survive on infected fallen leaves for an extended period of up to five months. During periods of favourable, warm and wet weather, the fungus could be transferred to a susceptible host by wind or rain splash.

The requirement for specific environmental conditions for sporulation, dispersal and infection, and the limited availability of susceptible host material and developmental stages in which hosts are most susceptible collectively support a likelihood estimate for distribution of 'Low'.

Overall likelihood of entry

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

The likelihood that *P. punicae* will enter Australia as a result of trade in pomegranate whole fruit from India and be distributed in a viable state to a susceptible host is assessed as: **Very Low**.

4.10.2 Likelihood of establishment

The likelihood that *P. punicae* will establish within Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- The recorded geographic distribution of *P. punicae* indicates that the pathogen is well-established in humid tropical and subtropical environments. Greater disease severity is observed in warm and wet conditions. For example, high levels of fruit spot severity have been reported in warm (20°C to 30°C), humid (84% relative humidity or above) and rainy conditions (Phengsintham et al. 2011; Samuel 1995).

- Climatic conditions in parts of Australia where pomegranate is grown are similar to those in countries where *P. punicae* has been reported, suggesting that climate is unlikely to prevent the establishment of this pathogen in Australia (Bureau of Meteorology 2018).
- Although Australia is free of *P. punicae*, some *Cercospora* species have established in Australia on a range of hosts (Farr & Rossman 2020; Plant Health Australia 2020), indicating the potential suitability of the environment for this species.
- The possible reproductive strategies of *P. punicae* are likely to be similar to those of some *Cercospora* species, including ability to initiate an infection through natural openings (Pohronezny, Simone & Kotze 1994; Solheim 1930; Wolf 1927), and may support its establishment in Australia when the environmental conditions are too cold or hot and dry.
- The establishment of *P. punicae* would be restricted due to the limited availability of hosts in Australia. The known host range of *P. punicae* is restricted to pomegranate. Pomegranate is grown as a fruit tree and ornamental garden shrub in Australian households (RIRDC 2014). However, pomegranate is a deciduous tree, which typically does not retain leaves during winter in temperate parts of Australia, limiting the availability of a host to support infection.
- To compensate its heavy dependence on environmental conditions for sporulation, dispersal and infection, the fungus is well-adapted to survive adverse conditions between crop cycles. *Pseudocercospora punicae* can survive in infected leaves and fruits for up to five months, forming thick-walled resting structures (Samuel 1995). Cells in these structures in other species of *Pseudocercospora* are known to reanimate during warm rainy weather giving rise to a large number of infectious spores which can initiate infections (Pohronezny, Simone & Kotze 1994).

Environmental conditions in some parts of Australia are suitable for *P. punicae*, and its presumed reproductive strategy, including the ability to infect hosts through natural openings and remain viable for extended periods during unfavourable environmental conditions, are likely to enable the pathogen to establish in Australia. These factors would be moderated by limited availability of susceptible states of its host and limited durations of favourable weather for its reproduction. These factors support a likelihood estimate for establishment of 'Moderate'.

4.10.3 Likelihood of spread

The likelihood that *P. punicae* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pathogen is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- Environmental conditions in some parts of pomegranate production areas in Australia are favourable for the spread of the fungus. Wide distribution of some *Cercospora* species in Australia (Farr & Rossman 2020; Plant Health Australia 2020) indicates the general suitability of the environment for fungal spread.
- Spread of *P. punicae* would be restricted due to the limited availability of hosts in Australia. The known natural host range of *P. punicae* is restricted to pomegranate, and commercial pomegranate production in Australia, while widely dispersed, is of relatively low density. Pomegranate is grown as a fruit tree and ornamental garden shrub in Australian households (RIRDC 2014). However, pomegranate is a deciduous tree, which typically does not retain

leaves during winter in temperate parts of Australia, limiting the availability to support infection.

- Leaf lesions produce more infectious spores than those on fruit, and hence are considered the main source of inoculum for the spread of the pathogen by natural means (Wolf 1927). The fungus persists on infected foliage in areas where pomegranate retains some of its foliage throughout the year. The growth of pomegranate plants is seasonal in areas experiencing cooler winters in Australia, which may also limit the spread of the fungus.
- *Pseudocercospora punicae* has effective dispersal strategies. The fungus readily spreads over short distances via rain splash and wind-blown rain and over long distances through mechanical means such as pruning tools (Pohronezny, Simone & Kotze 1994). Sprinkler irrigation used in some pomegranate orchards (Mckay 2018) may also favour the spread of the fungus within the orchards.
- The presence of natural barriers in Australia may limit the spread *of P. punicae*. Natural barriers such as arid areas, mountain ranges, climatic differentials and possible long distances between suitable hosts in parts of Australia, may prevent long-range natural spread of this bacterium.
- Long-distance spread of the fungus through infected fruits is not likely as fruit with mature stages of infection will show symptoms. Interstate quarantine controls on the movement of nursery stock and horticulture produce are also in place in Australia, which may reduce the likelihood of interstate spread of the fungus. However, there is a possibility that propagative material with early stages of infection and showing no visible symptoms could spread the fungus within Australia.
- The possibility of control of this fungus by natural enemies in Australia cannot be determined as there are no known reports of biological control attempts of *P. punicae* in pomegranate.

Suitable environmental conditions for the spread of *P. punicae* exist in parts of Australia. The fungus has effective dispersal strategies for short- and long-distance spread. The spread of *P. punicae* would be restricted due to the limited availability of suitable host material, lack of favourable environmental conditions some times of the year, and interstate quarantine regulations. These factors support a likelihood estimate for spread of 'Moderate'.

4.10.4 Overall likelihood of entry, establishment and spread

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

The overall likelihood that *P. punicae* will enter Australia as a result of trade in pomegranate whole fruit from India, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is assessed as: **Very Low.**

4.10.5 Consequences

The potential consequences of the establishment of *P. punicae* in Australia have been estimated according to the methods described in Table 2.3.

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

Criterion	Estimate and rationale
Direct	
Plant life or health	D – Significant at the district level *Pseudocercospora punicae* reduces fruit yield and quality due to severe spotting on leaves, blotching of fruits and premature fruit drop (Phengsintham et al. 2011). Black, elliptical spots appear on twigs, causing them to desiccate and in severe cases the whole plant may die (Patil & Patil 2014; Reddy 2010). Cercospora fruit spot is a mild to moderately severe disease in India and disease incidence of up to 32% has been reported (ICAR 2012; Samuel 1995). It also causes severe leaf spot and defoliation of pomegranate plants in Japan (Kobayashi & Kawabe 1992). Losses largely depend on seasonal variations in the weather and can be managed by employing standard orchard management practices. The commercial pomegranate industry is small in Australia. In 2014, there were about 500 hectares of commercial pomegranate orchards in Australia producing about 4,000 tonnes per year (AgriFutures Australia 2017b). The disease does not establish, or is of little importance, in dry and cooler temperate areas as it requires warm, rainy and humid environments for spore production and infection.
Other aspects of the environment	A – Indiscernible at the local level No impact of the pathogen has been reported on the environment. Valid host records of *P. punicae* are restricted to pomegranate and there is no evidence of potential for the fungus to infect native or endangered flora.
Indirect	
Eradication, control	D – Significant at the district level It is expected that efforts would be taken to contain and possibly eradicate an incursion of *P. punicae* within Australia. Any eradication effort would likely require the destruction of infected or potentially infected plant material in pomegranate orchards or nurseries, affecting economic viability of production. In India, *P. punicae* is managed by applying a combination of fungicides (Kumari 2017; Phengsintham et al. 2011) and cultural methods such as destruction of infected fruits and leaves, and pruning and destruction of twigs (Patil & Patil 2014). Standard production practices are already employed in well-managed pomegranate orchards (such as use of certified planting material, monitoring crop health, orchard sanitation) would also be used to control *P. punicae* (AgriFutures Australia 2017b). A number of fungicides that are registered for use on *Cercospora* species infecting other horticultural commodities (APVMA 2019) may be effective in controlling *P. punicae*. In addition, emergency permits for fungicides can be applied for and obtained within reasonable timeframe. However, any eradication, containment or control action incurs a cost, particularly chemical control in response to a *P. punicae* incursion.
Domestic trade	D – Significant at the district level The introduction of *P. punicae* into Australia would be expected to result in domestic movement restrictions on pomegranate fruit. The Australian pomegranate industry is focused on the domestic market and small-scale producers sell fruits to retailers or in local markets (AgriFutures Australia 2017b). Compliance with domestic biosecurity requirements would impose additional costs for producers. Given that the spread of the fungus between regions primarily occurs through infected planting material, restrictions on movement and trade of pomegranate planting material between production areas may be required.
International trade	C – Minor significance at the district level *P. punicae* is not currently regulated by Australia's trading partners on pomegranate fruit or nursery stock exports.

	Australia currently has export market access for pomegranate fruit to Fiji, Indonesia, Nauru, Papua New Guinea, Qatar, Singapore, Tonga and United Arab Emirates. If *P. punicae* established, trading partners may review their phytosanitary requirements for affected commodities. Existing market access would need to be re-established and opening of new markets would be difficult. This would threaten economic viability.
Non-commercial and environmental	A – Indiscernible at the local level There are currently no known direct consequences of *P. punicae* on the environment. Chemical application to control the disease could affect the environment, but it is not expected to have any greater effect than the present use of agrochemicals. Indirect effects on native plants from fungicide applications are also expected to have indiscernible consequences.

4.10.6 Unrestricted risk estimate

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

Unrestricted risk estimate for *Pseudocercospora punicae*	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Low
Unrestricted risk	Negligible

The unrestricted risk estimate for *P. punicae* has been assessed as Negligible, which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for *P. punicae* on this pathway.

4.11 Ripe rot

Coleophoma empetri (Rostr.) Petr

Coleophoma empetri causes fruit rot primarily in cranberry (Caruso & Ramsdell 1995), and has been reported to cause fruit spot on pomegranate (Sherkar, Utikar & More 1980). This coelomycete fungus is known to be plant pathogenic, as well as saprobic and endophytic. It occurs on a wide range of host plants, and there are reports of *C. empetri* causing damage to cowpea, pomegranate, potato and tomato (Crous & Groenewald 2016; Lodha, Gupta & Singh 1986; Patel & Vaishnav 1992; Patil & Raut 1991; Sherkar, Utikar & More 1980).

Coleophoma empetri has been reported on pomegranate, causing leaf and fruit spots, in Maharashtra, India (Sherkar, Utikar & More 1980). On fruits, symptoms develop as numerous, minute, circular small brown spots which darken as they mature. The spots coalesce to form irregular depressions and hard necrotic lesions, which are restricted to the fruit epidermis and bear black-reddish pycnidia. The spots on leaves develop into large blotches that eventually cause the leaf to fall from the tree (Sherkar, Utikar & More 1980).

Limited research has been conducted on the dispersal methods of *C. empetri*. It is expected that, similar to other coelomycete fungi, short-range dispersal is possible by water splash (Oudemans et al. 2005) and long-range dispersal may be aided by wind and storms and the movement of propagative material. Dispersal by wind-blown water is much more common in coelomycetes than wind-dispersal (Cole 1981).

Although damage has been reported in very few hosts, *C. empetri* has been isolated from a wide variety of species and also from soil (Abdel-Aziz 2016; Deena & Basuchaudhary 1984; Duan, Wu & Liu 2007; Grishkan & Nevo 2010; Joshi & Chauhan 1982; Kowalik, Kierpiec & Żołna 2012; Patel & Vaishnav 1992; Patil & Raut 1991; Sherkar, Utikar & More 1980; Sutton 1980).

Coleophoma empetri has been reported to occur in Canada (Gourley 1979), Egypt (Abdel-Aziz 2016), India (Sherkar, Utikar & More 1980), Israel (Grishkan & Nevo 2010), Poland (Kowalik, Kierpiec & Żołna 2012), Saudi Arabia (Al-Dhabaan & Bakhali 2016) and the USA (McManus 2001b).

Coleophoma empetri is not present in Australia and is therefore a pathogen of biosecurity concern for all of Australia.

The risk scenario of biosecurity concern for *C. empetri* is that there may be potential for symptomless infected pomegranate whole fruit to be imported into Australia.

4.11.1 Likelihood of entry

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

Likelihood of importation

The likelihood that *C. empetri* will arrive in Australia through the importation of pomegranate whole fruit from India is assessed as: **Very Low.**

The following information provides supporting evidence for this assessment.

- *Coleophoma empetri* has been reported from the pomegranate growing areas of India, where it has been isolated from pomegranate fruit and leaves (Sherkar, Utikar & More 1980).
- This fungus has not been widely reported in India, although there are isolated reports on hosts other than pomegranate. These include on bael (*Aegle marmelos*) in the Western Ghats, Goa State, on potato (*Solanum tuberosum*) in Jamnagar, Gujarat, and on cowpea (*Vigna unguiculata*) in arid zones of Rajasthan (Gawas-Sakhalkar & Bhat 2010; Lodha, Gupta & Singh 1986; Patel & Vaishnav 1992). A lack of reporting about this fungus, particularly on pomegranate as compared to other major pomegranate pests, suggests that pomegranate is not a major host of this fungus, and possibly that its prevalence is likely to be low in pomegranate orchards.
- There is limited literature describing the symptoms of *C. empetri* on pomegranate fruit. Sherkar, Utikar & More (1980), described the symptoms of infection as many small brown spots, which darken in colour and coalesce into hard, depressed lesions on the fruit rind. In its primary host, cranberry, *C. empetri* has been isolated from healthy ovaries and fruit, with rot symptoms only showing in later stages of fruit development or during storage (Caruso & Ramsdell 1995; Stiles & Oudemans 1999). It is possible that infected pomegranate whole fruit may not show disease symptoms.
- Symptomatic fruit are not marketable, and are likely to be discarded during packing house processes; therefore, fruit with obvious external symptoms are less likely to be imported. However, mature fruit infected just prior to harvest that have not developed visible external symptoms could be exported to Australia.
- *Coleophoma empetri* is likely to survive storage and transport. In studies of fruit rots in cranberry, *C. empetri* was isolated from berries which showed no symptoms at collection and were stored at 5°C for up to four months (Vilka, Rancane & Eihe 2009). This fungus has also been reported to overwinter in cranberry fruit (Caruso & Ramsdell 1995). It is likely that *C. empetri* would survive proposed storage and transport temperatures of about 5°C to 8°C.

Pomegranate is not a primary host of *C. empetri* and very limited reporting of its presence on pomegranate suggests that it is not prevalent in pomegranate orchards. It is possible that the fungus can cause inapparent infection (Caruso & Ramsdell 1995; Stiles & Oudemans 1999) and, therefore if present on pomegranate fruit, that symptoms may not show on infected fruit. The fungus is likely to survive under storage and transport conditions. However, limited evidence of its association with pomegranate whole fruit suggests any association is likely to be low. These factors support a likelihood estimate for importation of 'Very Low'.

Likelihood of distribution

The likelihood that *C. empetri* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of pomegranate from India, and subsequently transfer to a susceptible host is assessed as: **Low**.

The following information provides supporting evidence for this assessment:

- Imported pomegranate whole fruit would be distributed for sale to various destinations in Australia. They may be distributed through large fresh produce wholesale markets to retail outlets, and then to consumers. Distribution of infected fruit would facilitate the distribution of *C. empetri*.

- *Coleophoma empetri* is likely to survive storage and transport. In studies of fruit rots in cranberry, *C. empetri* has been reported to survive storage at 5°C for up to four months (Vilka, Rancane & Eihe 2009) and to overwinter in cranberry fruit (Caruso & Ramsdell 1995). It is likely that *C. empetri* would survive proposed storage and transport temperatures of about 5°C to 8°C.
- Pomegranate fruit have a thick leathery rind and arils need to be extracted for consumption. Therefore, infested pomegranate waste is likely to be disposed of as municipal waste, from where it is unlikely to distribute *C. empetri* into the environment. However, pomegranate waste disposed of as litter may be deposited into urban, peri-urban and agricultural situations, as well as areas of natural vegetation.
- *Coleophoma empetri* has been reported to survive in a wide range of conditions, including conditions similar to those expected for waste material in the natural environment. In studies of fruit rots in cranberry, *C. empetri* was isolated from cranberry ovaries which were stored at room temperature (22°C) for 14 weeks (Tadych et al. 2012). In cranberry beds, *C. empetri* survived in leaf litter, on decaying leaves, fruit and debris (Caruso & Ramsdell 1995; McManus 2001b; Oudemans et al. 2005).
- Under laboratory conditions, Patil and Raut (1991) found that the best growth from conidial inoculation was achieved at 28°C to 30°C and relative humidity of 80% to 90%. Sherkar, Utikar and More (1980) found that optimum growth was achieved at 27.3°C, while minimum and maximum temperatures for growth were 5°C and 40°C respectively under laboratory conditions. Therefore, temperature is unlikely to be a constraint on growth, but low humidity in many parts of Australia may limit the ability of the fungus to grow and produce reproductive structures for dispersal.
- In cranberry, the primary source of infection is leaves rather than fruit, which is believed to be a very minor source of inoculum due to the low number of fruit remaining in cranberry beds following harvest (McManus 2001b). However, given that cranberry fruit may provide some inoculum, a low possibility that *C. empetri* may also sporulate on discarded pomegranate fruit cannot be ruled out.
- Limited research has been conducted on the spore production and dispersal methods of *C. empetri.* Preliminary studies on cranberry fruit rot indicate that *C. empetri* spores can be dispersed by water splash and propagative material (Oudemans et al. 2005).
- A large number of host plant species are widely distributed in Australia. Host plants include chilli (*Capsicum annuum*), *Eucalyptus* species, fig (*Ficus species*), ash (*Fraxinus species*), honeysuckle (*Lonicera periclymenum*), water lily (*Nymphaea alba*), common reed (*Phragmosis australis*), cherry laurel (*Prunus laurocerasus*), pomegranate (*Punica granatum*), azalea (*Rhododendron species*), tomato (*Solanum lycopersicum*) and potato (*Solanum tuberosum*) (Abdel-Aziz 2016; CDFA 2020; Deena & Basuchaudhary 1984; Duan, Wu & Liu 2007; Kowalik, Kierpiec & Żołna 2012; Patel & Vaishnav 1992; Patil & Raut 1991; Sherkar, Utikar & More 1980; Sutton 1980). The wide distribution of hosts on roadsides and in home gardens, parks and orchards could assist the spread of this fungus from infected imported fruit to a new host in Australia.

Coleophoma empetri on infected pomegranate whole fruit could be distributed across Australia and survive storage and transport. Many of the reported hosts are abundant and widely cultivated in Australia. Infested fruit may be discarded in the environment and it is possible that *C. empetri* could survive in pomegranate waste until conditions are favourable for sporulation, and that sporulation could occur on pomegranate fruit. The production of spores is likely to be limited by dry conditions in many parts of Australia. However, the majority of pomegranate waste will be disposed of via municipal waste systems. These factors support a likelihood estimate for distribution of 'Low'.

Overall likelihood of entry

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

The likelihood that *C. empetri* will enter Australia as a result of trade in pomegranate from India, and be distributed in a viable state to a susceptible host, is assessed as: **Very Low**.

4.11.2 Likelihood of establishment

The likelihood that *C. empetri* will establish in Australia based on a comparison of factors in the source and destination areas that affect pathogen survival and reproduction is assessed as: **High**.

The following information provides supporting evidence for this assessment:

- A large number of host plant species are widely distributed in Australia. Host plants include chilli (*Capsicum annuum*), *Eucalyptus* species, fig (*Ficus species*), ash (*Fraxinus species*), honeysuckle (*Lonicera periclymenum*), water lily (*Nymphaea alba*), common reed (*Phragmosis australis*), cherry laurel (*Prunus laurocerasus*), pomegranate (*Punica granatum*), azalea (*Rhododendron* species), tomato (*Solanum lycopersicum*) and potato (*Solanum tuberosum*) (Abdel-Aziz 2016; Deena & Basuchaudhary 1984; Duan, Wu & Liu 2007; Kowalik, Kierpiec & Żołna 2012; Patel & Vaishnav 1992; Patil & Raut 1991; Sherkar, Utikar & More 1980; Sutton 1980). The distribution of hosts on roadsides and in home gardens, parks and orchards could assist the establishment of this fungus.
- Suitable environmental conditions for establishment exist in Australia. *Coleophoma empetri* is very resilient and survives in a wide range of environmental conditions. It occurs in acidic cranberry bogs in northern USA in a humid cool summer climate (Goode's World Atlas 2005; Oudemans, Caruso & Stretch 1998), on aquatic plant species in ponds in southern Poland, which has a mild winter climate (Goode's World Atlas 2005; Kowalik, Kierpiec & Żołna 2012), and in sands in the Negev Desert, Israel in a tropical/subtropical desert climate (Goode's World Atlas 2005; Grishkan & Nevo 2010). In India it has been reported on potato in Gujarat, on tomato and pomegranate in Maharashtra and on sword-bean (*Canavalia gladiata*) in Andra Pradesh (Philip 2014), showing its potential to establish under tropical and subtropical climates.
- *Coleophoma empetri* has a suitable reproductive strategy for establishment in Australia. The fungus is well adapted to survive adverse conditions. In cranberry beds, the fungus overwinters as mycelium or immature pycnidia on organic debris. With a new season of cranberry flowering and fruit development, *C. empetri* begins to release new spores (Caruso & Ramsdell 1995; Oudemans et al. 2005).

- Chemical and cultural pest control practices of horticultural crops applied in Australia may have some impact on the establishment of *C. empetri*; however, the effectiveness of these practices against this pathogen is unknown and many reported hosts that are abundant in the Australian environment are not managed for pests, potentially enabling the pathogen to find a variety of alternative hosts.

Coleophoma empetri has a wide range of hosts available in Australia on roadsides, in home gardens, parks and orchards, ranging from annual horticulture crops to perennial shrubs and trees. The fungus is resilient and can survive in a wide range of environmental conditions, including by overwintering, and can infect hosts when the environmental conditions become suitable. Some of the existing chemical and cultural pest control practices aimed at other pests may have some impact on this pathogen; however, many alternative hosts that are abundant in Australia have no pest control applied to them. These factors support a likelihood estimate for establishment of 'High'.

4.11.3 Likelihood of spread

The likelihood that *C. empetri* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pathogen, is assessed as: **High**.

The following information provides supporting evidence for this assessment.

- Suitable environmental conditions for spread exist in Australia. *Coleophoma empetri* occurs in a wide range of environmental conditions, including in humid cool-summer climates in northern USA (Goode's World Atlas 2005; Oudemans, Caruso & Stretch 1998), in mild winter climates in southern Poland (Goode's World Atlas 2005; Kowalik, Kierpiec & Żołna 2012), and in tropical/subtropical desert climates in Negev Desert, Israel (Goode's World Atlas 2005; Grishkan & Nevo 2010). These occurrences indicate that there would be suitable climate/environment niches for its spread in Australia.
- Host plants are widely distributed in Australia. The wide distribution of host plants on roadsides and in home gardens, parks and orchards assist the spread of this fungus. *Coleophoma empetri* has also been isolated from soil (Grishkan & Nevo 2010; Joshi & Chauhan 1982). However, no information exists on how long *C. empetri* could remain viable in soil.
- *Coleophoma empetri* has effective dispersal strategies for short-distance spread. *Coleophoma empetri* conidia can be dispersed by water splash (Oudemans et al. 2005) However, no information is available in the literature on the distance over which conidia of *C. empetri* can be carried.
- Water-splash driven dispersal of spores and infected leaves could aid the spread of this fungus similar to other pycnidia-forming fungal pathogens. *Coleophoma empetri* has been isolated from the leaves of many hosts, including cranberry, pomegranate, rhododendron and cowpea (Kowalik, Kierpiec & Żołna 2012; Lodha, Gupta & Singh 1986; McManus 2001b; Sherkar, Utikar & More 1980).
- Human-assisted dispersal of propagative material could aid the long-distance spread of *C. empetri*. Studies of the distribution of *C. empetri* across northern USA showed that the species is genetically identical across the region, suggesting the fungus has spread via

planting material (Polashock et al. 2009). Studies of *C. empetri* occurrence in Latvia have also suggested that the fungus may have been imported with cranberry seedling material (Vilka, Rancane & Eihe 2009).

- Natural barriers in Australia, including arid areas and climatic differences, are less likely to prevent spread as the pathogen is reported from a wide range of environments with harsh conditions. Pomegranate orchards are relatively few in number and isolated in Australia; however, alternative hosts including horticultural crops and native trees are abundant and likely to enable spread.

Coleophoma empetri is reported to survive in a wide range of harsh environmental conditions, and the many host plants available in natural and managed environments in Australia are likely to aid its spread. Although pomegranate orchards are relatively isolated in Australia, there are many alternative hosts that are abundant and that could enable its spread. Short- and long-distance dispersal mechanisms, both aided and unaided, enhance its likelihood of spread across Australia. These factors collectively support a likelihood estimate for spread of 'High'.

4.11.4 Overall likelihood of entry, establishment and spread

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

The likelihood that *C. empetri* will enter Australia as a result of trade in pomegranate from India, be distributed in a viable state to a susceptible host, establish in Australia, and subsequently spread within Australia is assessed as: **Very Low**.

4.11.5 Consequences

The potential consequences of the establishment of *C. empetri* in Australia have been estimated according to the matrix of rules described in Table 2.3.

Based on the decision rules described in Table 2.4, that is, where the potential consequences of a pest with respect to one or more criteria are 'C', the overall consequences are estimated to be **Very Low**.

Criterion	Estimate and rationale
Direct	
Plant life or health	C – Minor significance at district level Cranberry is the primary host for *C. empetri*, which is a causal agent for field and storage rots (McManus 2001a). Cranberries are not currently produced commercially in Australia. There are isolated reports of *C. empetri* infecting and causing damage to pomegranate, potato and tomato (Patel & Vaishnav 1992; Patil & Raut 1991; Sherkar, Utikar & More 1980). However, no economic losses have been reported on any commodities other than cranberry.
Other aspects of the environment	A – Indiscernible at the local level There are currently no known direct consequences of *C. empetri* on other aspects of the natural environment.
Indirect	
Eradication, control	B – Minor significance at the local level Eradication and control of *C. empetri* would be difficult as it can survive in a wide variety of hosts, and also in soil.

	Chemical and physical control methods which are partially effective in controlling *C. empetri* in cranberry include application of broad-spectrum fungicides, sanding cranberry beds to cover organic debris and dry-harvesting fruit (McManus 2001b; Oudemans, Caruso & Stretch 1998). Broad-spectrum fungicides currently used in Australia are likely to be effective also for *C. empetri* control. A number of broad-spectrum fungicides are registered for use on horticultural commodities (APVMA 2019).
Domestic trade	B – Minor significance at the local level Significant damage by *C. empetri* has only been reported on cranberry, which is not commercially grown or traded in Australia.
International trade	C – Minor significance at district level Significant damage by *C. empetri* has only been reported on cranberry, which is not commercially grown in or exported from Australia.
Non-commercial and environmental	A – indiscernible at the local level There are currently no known direct consequences of *C. empetri* on the environment. Broad-spectrum fungicides which may be used to control *C. empetri* are already in use in Australia. Any additional usage of chemical sprays may affect the environment, but may not have any greater effect than present pest management methods.

4.11.6 Unrestricted risk estimate

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

Unrestricted risk estimate for *Coleophoma empetri*	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Very Low
Unrestricted risk	Negligible

The unrestricted risk estimate for *C. empetri* has been assessed as ‘Negligible’, which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for *C. empetri* on this pathway.

4.12 Pomegranate scab

***Elsinoë punicae* (Bitanc. & Jenkins) Rossman & Allen (Synonym: *Sphaceloma punicae*)**

'Scab' is the common name used for diseases caused by members of the genus *Elsinoë*. A number of these species were described previously in its asexually typified genus *Sphaceloma*. In advancing to one scientific name for each fungus species (McNeill & Turland 2011), *Sphaceloma* is now considered a synonym of *Elsinoë* (Rossman, Allen & Castlebury 2016).

Pomegranate scab disease is caused by *Elsinoë punicae*, which occurs primarily in subtropical and tropical regions (Rossman, Allen & Castlebury 2016). The natural host range of *E. punicae* is restricted to pomegranate (Fan et al. 2017; Rossman, Allen & Castlebury 2016). The fungus infects fruits, leaves, petioles and twigs of the pomegranate plant throughout its growing range (Carstens et al. 2018; Fan et al. 2017; Rossman, Allen & Castlebury 2016). Irregular, brown to black, wart-like outgrowths (scab lesions/pustules) are formed on the fruit, which reduce the marketability of pomegranate fruits (Carstens et al. 2018).

India is one of the endemic ranges for *E. punicae* (Fan et al. 2017; Jamadar et al. 2011). Drizzling rains and abundant dew favour development and spread of *E. punicae* in India (Jamadar et al. 2011). Disease incidence of *E. punicae* varies throughout India, depending on climatic conditions (ICAR 2017).

E. punicae is not known to occur in Australia, therefore, it is a pest of biosecurity concern for Australia.

Biological and pathogenic characteristics of *E. punicae* are not well documented in the literature. However, it is expected that the characteristics of *E. punicae* would be similar to those of other species in the genus, particularly to phylogenetically closely related species (e.g. *E. australis, E. fawcettii, E. anacardi, E. rosarum* and *E. piri*)((Carstens et al. 2018), which cause scab diseases on other fruit commodities such as citrus.

Elsinoë species propagate primarily via asexual spores (conidia) which spread via rain splash, irrigation water, insects and short distances by wind (CABI EPPO 2003; Whiteside 1975). Conidia are produced in small asexual fruiting bodies (acervuli) on the edge of scab pustules (Timmer 2000). Conidia are fragile and die quickly if they are exposed to sunlight or dry conditions (CABI EPPO 2003; Timmer 2000).

Similar to other *Elsinoë* species, *E. punicae* is expected to infect fruit when they are young; fruit become resistant to infection once they develop to full size (Tsatsia & Jackson 2017). Pomegranate requires about 14 weeks for fruit to develop and mature (AgriFutures Australia 2017b).

The risk scenario of biosecurity concern for *E. punicae* is that the fungus may be present on infected whole fruit with less evident scab lesions, from which the pathogen may subsequently establish in Australia.

4.12.1 Likelihood of entry

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

Likelihood of importation

The likelihood that *E. punicae* will arrive in Australia with the importation of pomegranate whole fruit from India is assessed as: **Low.**

The following information provides supporting evidence for this assessment.

- *Elsinoë punicae* has been reported from the pomegranate growing areas of India, which is one of the endemic ranges for *E. punicae* (Carstens et al. 2018; Fan et al. 2017; Jamadar et al. 2011; Rossman, Allen & Castlebury 2016; Thieumalachar 1946). Pomegranate scab is considered a minor disease although it is becoming a concern in India (Jamadar et al. 2011).
- Disease incidence of up to 100% has been reported in an adopted pomegranate orchard, where the history of pest management was not reported in Solapur, Maharashtra (ICAR 2012). However, scab incidence is much lower in other areas, e.g. 1% to 5% in northern Karnataka (Benagi et al. 2011) and to a maximum of 4.5% in Pune (ICAR 2017). This range could be attributed to climatic variations or management procedures. Some germplasm lines grown in India are either disease resistant or tolerant to scab disease (e.g. display less than 10% incidence) (ICAR 2017).
- There is limited information available on the disease cycle of *Elsinoë punicae*; however, other *Elsinoë* species are reported to infect the fruit (as well as leaves and twigs) when they are young and fruit become resistant to infection once they reach full size (CABI EPPO 2003; Tsatsia & Jackson 2017). Young pomegranate fruits infected by *E. punicae* have irregular, brown to black lesions which harden with age forming slightly raised, wart-like outgrowths (scab lesions/pustules). The peel may crack or split due to scab lesions, resulting in severe external disfigurement of the pomegranate fruit (Thieumalachar 1946). Infections by *Elsinoë* species usually do not result in development of internal fruit symptoms (Carstens et al. 2018).
- Similar to other *Elsinoë* species, *E. punicae* is expected to infect fruit when they are young, and fruit are predicted to become resistant to infection once they develop to full size (Tsatsia & Jackson 2017). Harvested pomegranate fruit inoculated with *E. punicae* mycelial suspension under experimental conditions did not develop symptoms within two months (Carstens et al. 2018). Since pomegranate fruit requires 14 weeks to mature (AgriFutures Australia 2017b), any fruit that is infected when immature is likely to express symptoms before it is harvested. Therefore, asymptomatic fruit is not considered a likely pathway for the introduction of *E. punicae* into Australia.
- *Elsinoë punicae* symptoms are likely to be detected during packing house processes. Depending on the fruit variety or environmental conditions, scab lesions on the fruit may be variable (CABI EPPO 2003). Lightly-infected fruit with less evident scab lesions, or which do not display a strongly affected external appearance, may go undetected during packing house processes. Therefore, importation of infected fruit cannot be entirely ruled out, and fruit which may be undetected during commercial packing house processes may be exported to Australia.
- Fruit is typically stored and transported in refrigerated containers maintained at 5°C to 8°C. While no specific information is available on the lower temperature threshold for survival of *E. punicae*, other *Elsinoë* species have been reported to survive, and spores to have

germinated at 5°C, suggesting that transport and storage conditions are unlikely to have an impact on the survival of *E. punicae* (Minutolo et al. 2016).

- Standard processing applied at packing houses including air blowing, disinfection and washing, would reduce but not necessarily eliminate infected tissue on the rind.

Elsinoë punicae is present in pomegranate production areas in India, and pomegranate fruit is a host for the fungus; however, disease incidence is generally low in managed pomegranate orchards. The fungus primarily infects immature fruit; therefore, symptoms are likely to appear before harvest, and it is consequently likely that affected fruit will be removed from the export pathway. However, lightly-infected fruit with less evident scab lesions may go undetected during packing house processes and the pest is likely to survive storage and transport. These factors collectively support a likelihood estimate of importation of 'Low'.

Likelihood of distribution

The likelihood that *E. punicae* will be distributed in a viable state within Australia with imported pomegranate whole fruit from India and transferred to a suitable host, is assessed as: **Very Low**.

The following information provides supporting evidence for this assessment.

- Pomegranate whole fruit would be distributed for sale to various destinations in Australia. They may be distributed through large fresh produce wholesale markets and then to supermarkets or other sellers, or directly to smaller retailers and then to consumers. Distribution of infected fruit would facilitate the distribution of *E. punicae*.
- Fruit is typically stored and transported in refrigerated containers maintained at 5°C to 8°C. While no specific information is available on the lower temperature threshold for survival of *E. punicae*, other *Elsinoë* species have been reported to survive, and spores to have germinated at 5°C, suggesting that transport and storage conditions are unlikely to have an impact on the survival of *E. punicae* (Minutolo et al. 2016).
- Pomegranate fruit has a thick leathery rind and arils need to be extracted for consumption. Pomegranate waste is likely to be disposed of as municipal waste, from where it is unlikely to distribute *E. punicae* into the environment. However, small quantities of fruit waste may be discarded as litter in domestic compost, urban and rural natural environments throughout Australia.
- For infected fruit/waste to transmit *E. punicae* to a susceptible host, it must be placed or discarded in the vicinity of growing pomegranate plants, the fungus must survive on the waste, and environmental conditions must be conducive for conidia production, germination, infection and disease development.
- The availability of host species for *E. punicae* is limited in Australia as its only host, pomegranate, is commercially grown only over some 500 hectares, confined to the Murray–Darling Basin, St. George, Shepparton, Lachlan, Murrumbidgee, Riverina, Murray and Riverland valleys and in Western Australia near Carnarvon and south of Perth (AgriFutures Australia 2017b). Pomegranate, although not common, is grown as a fruit tree and an ornamental garden shrub in Australian households (RIRDC 2014).
- Information on the ability of the pathogen to survive in pustules on the rind is not available. However, *Elsinoë punicae* may be able to survive in pomegranate waste material, as other

Elsinoë species were reported to be able to survive in scab pustules on fruit remaining on trees and on other plant parts (CABI EPPO 2003; Timmer 2000). However, survival of a pathogen in unmanaged fruit waste is generally expected to be of limited duration due to waste desiccation, and competition from other saprophytic organisms under wet conditions.

- It is possible that *E. punicae* could transfer from waste material to a suitable host. Similar to other scab-causing fungi (Timmer 2000), *E. punicae* conidia could spread via rain splash and be airborne for short distances. Air-borne water droplets carrying splash-liberated inoculum can be carried by the wind for short distances (Whiteside 1975). Conidia can also be liberated and aerially dispersed by wind (Whiteside 1975).
- A morphological and cultural analysis of *E. punicae* isolated from pomegranate fruit scab lesions showed that *E. punicae* produce only hyaline conidia (Carstens et al. 2018). There is no report that on *E. punicae* can produce pigmented conidia, which are more resistant to desiccation and survive longer in the environment (Gottwald 1995).
- The potential for distribution is likely to be further reduced by the unique set of conditions that are required for infection to occur within the period that spores may survive. *Elsinoë punicae* conidia, similar to those of other *Elsinoë* species, are likely to be fragile and die quickly if they are exposed to sunlight or dry conditions (CABI EPPO 2003; Timmer 2000).
- Similar to other *Elsinoë* species, *E. punicae* is likely to require pomegranate plants to be in the most susceptible developmental stage in order to initiate and sustain an infection, i.e. trees with new vegetative flushes and young fruits (Chung 2011). Although pomegranates from India will be imported throughout the year, transfer of the fungus to a suitable host would be most probable during spring and early summer.
- Pomegranate seed is not considered to be a pathway for the distribution of *E. punicae* as the fungus is not known to be seed-borne in pomegranate.

Distribution of infected fruit would facilitate the distribution of *E. punicae* throughout Australia. However, the only reported host, pomegranate, has a limited distribution in Australia and the fungal spores have limited potential for long-distance dispersal from discarded waste. The majority of fruit waste or discarded fruits will be discarded through managed waste systems which are unlikely to provide a viable transmission pathway to a suitable host. *Elsinoë punicae* conidia could survive in scab pustules on the fruit waste, and germinate when exposed to favourable temperatures and moisture. Conidia are fragile with poor survival potential in adverse conditions, and have specific requirements for sporulation, dispersal and infection; there is limited availability in Australia of susceptible hosts and developmental stages in which hosts are most susceptible. These factors collectively support a likelihood estimate for distribution of 'Very Low'.

Overall likelihood of entry

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

The likelihood that *E. punicae* will enter Australia as a result of trade in pomegranate whole fruit from India and be distributed in a viable state to a susceptible host is assessed as: **Very Low**.

4.12.2 Likelihood of establishment

The likelihood that *E. punicae* will establish within Australia based on a comparison of factors in the source and destination areas that affect pest survival and reproduction is assessed as: **Moderate**.

The following information provides supporting evidence for this assessment.

- The availability of host plants of *Elsinoë punicae* is limited in Australia. Species of *Elsinoë* have narrow host ranges, mostly limited to a single host species, and the natural host range of *E. punicae* is restricted to pomegranate (Fan et al. 2017).
- The current geographic distribution of *E. punicae* indicates that the pathogen is well established in humid tropical and subtropical environments (Rossman, Allen & Castlebury 2016). The climates in pomegranate growing areas in Australia are largely temperate and dry, which is likely to limit the establishment of *E. punicae*.
- Sporulation, spore dispersal and infection by *Elsinoë* species are strongly influenced by environmental conditions. Conidia are fragile and susceptible to desiccation. If conditions are not suitable for infection, conidia are unlikely to persist in the environment.
- The optimal temperature ranges for infection and disease development of the closely related species *E. australis* and *E. fawcettii* have been reported as 14°C to 25°C and 20°C to 21°C, and a minimum wet period of two to three hours is critical for infection (CABI EPPO 2003). It is expected that similar conditions are required for infection and disease development of *E. punicae*.
- *Elsinoë punicae* has effective reproduction and adaptation strategies. Although Australia is free of *E. punicae*, the related species *E. australis* is present in citrus-growing areas of Australia (Farr & Rossman 2020; Plant Health Australia 2020), which may indicate potential suitability of the environment for other species of the genus.
- Pomegranate plants need to be in a susceptible state for disease establishment by *E. punicae* (i.e. when the plants are actively growing and when leaves and fruits are available), and be in close proximity to inoculum as fungal spores are expected to be carried by wind, rain splash or insects only for short distances. Therefore, establishment would not be probable when the weather is hot or dry.
- *Elsinoë* species are able to overwinter in pustules on fruits and on other plant materials (twigs, leaves) providing the inoculum for the next season (CABI EPPO 2003; Chung 2011). According to Whiteside (1975), even on resistant cultivars the fungus can survive on diseased shoots originating from susceptible rootstocks. Similarly, *E. punicae* may survive adverse conditions between crop cycles in scab pustules on fruits, leaves or twigs. These cells may reanimate during mild, humid conditions giving rise to large numbers of infectious spores which may initiate infections on new flush.

Elsinoë punicae is host specific and the host species, pomegranate, is grown in limited areas in Australia, where the climate is largely temperate and dry. *Elsinoë* species are able to overwinter in pustules on fruits and on other plant materials (twigs, leaves) providing inoculum for the following season, and may survive adverse conditions between crop cycles in scab pustules on fruits, leaves or twigs. However, the fungus requires humid and wet conditions for spore (conidia) production and infection. Conidia are fragile and susceptible to desiccation and are unlikely to persist in dry environments for extended periods. *Elsinoë punicae* requires host plants in a susceptible state for disease infection. These factors support a likelihood estimate for establishment of 'Moderate'.

4.12.3 Likelihood of spread

The likelihood that *E. punicae* will spread within Australia, based on a comparison of factors in the source and destination areas that affect the expansion of the geographic distribution of the pest is assessed as: **Low**.

The following information provides supporting evidence for this assessment.

- Suitable environmental conditions for spread exist in Australia. The environmental conditions in some pomegranate production areas in Australia may favour the spread of the fungus. The presence of other *Elsinoë* species in Australia (Farr & Rossman 2020; Plant Health Australia 2020) indicates the suitability of the environment for fungal spread.
- Spread of *E. punicae* would be restricted due to the limited availability of host material in Australia. The natural host range of *E. punicae* is restricted to pomegranate and commercial pomegranate orchards are confined to a few regions. Pomegranates are also grown as fruit trees and/or ornamental garden plants in Australian households.
- Similar to other *Elsinoë* species, *Elsinoë punicae* has effective dispersal strategies for short-distance spread. Natural spread of scab pathogens from short to moderate distances within orchards occurs primarily by rain splash (CABI EPPO 2003; Chung 2011; Gopal et al. 2014; Timmer 2000; Whiteside 1975).
- Conidia may be dispersed over short distances in wind-blown water droplets, mostly within the tree canopy. Dew may also cause the spores to be liberated from the lesions, but due to the limited splashing action there would only be localised dispersal. Sprinkler irrigation used in some pomegranate orchards in Australia (Mckay 2018) favours the spread of the fungus within the orchards.
- Human-assisted long-distance spread occurs mainly through infected propagative material. Long-distance spread of the fungus through infected fruits would be rare as infected fruits are symptomatic and not likely to be of commercial quality. Further, dispersal from any infected fruit is likely to be very low. Interstate quarantine controls on the movement of nursery stock and horticultural produce in Australia may reduce the likelihood of interstate spread of the fungus.
- Natural barriers in Australia, including arid areas, climatic differences and long distances between pomegranate orchards and other hosts will limit the ability of *E. punicae* to disperse from one area to another unaided. The distance between pomegranate production sites is likely to be a significant factor limiting the spread of this pest.

Suitable environmental conditions for the spread of *E. punicae* exist in some parts of Australia. The fungus has effective dispersal strategies for short distances and limited opportunity for long-distance spread. The limited availability of suitable host material, the specific weather conditions required for sporulation and dispersal of spores, natural barriers in Australia and interstate quarantine regulations collectively support a likelihood estimate for spread of 'Low'.

4.12.4 Overall likelihood of entry, establishment and spread

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

The overall likelihood that *E. punicae* will enter Australia as a result of trade in pomegranate whole fruit from India, be distributed in a viable state to a susceptible host, establish in Australia and subsequently spread within Australia is assessed as: **Very Low**.

4.12.5 Consequences

The potential consequences of the establishment of *E. punicae* in Australia have been estimated according to the methods described in Table 2.3.

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

Criterion	Estimate and rationale
Direct	
Plant life or health	D – Significant at the district level Pomegranate scab is a moderately destructive to severe disease. Rusty spots appear on leaves and fruits (Carstens et al. 2018; Thieumalachar 1946). The presence of scab reduces the market value of fresh pomegranates (Carstens et al. 2018). Recently, scab has become a serious concern in India (Jamadar et al. 2011). However, losses largely depend on seasonal variations in the weather and the variety of pomegranate. The disease could be managed by employing standard orchard management practices (Gopal et al. 2014), The host range of *E. punicae* is restricted to pomegranate. The commercial pomegranate industry is small in Australia. In 2014, there were about 500 hectares of commercial pomegranate orchards in Australia producing about 4,000 tonnes per year (AgriFutures Australia 2017b). The disease does not establish in dry and hot areas and the majority of pomegranate is grown primarily in temperate/arid areas in Australia. However, *E. punicae* may cause losses to pomegranate crops where conducive environmental conditions prevail for disease establishment and spread.
Other aspects of the environment	A – Indiscernible at the local level No impact of the pathogen on the environment has been reported in the available literature. The host range of *E. punicae* is limited to pomegranate. There is no evidence to suggest that this fungus infects native or endangered flora.
Indirect	
Eradication, control	C – Significant at the local level It is expected that efforts would be taken to contain and possibly eradicate an incursion of *E. punicae* within Australia. Any eradication effort would likely require the destruction of infected or potentially infected plant material in pomegranate orchards or nurseries, affecting economic viability of production. In India, *E. punicae* is managed by applying combinations of fungicides such as 0.1% thiophanate methyl, 0.1% carbendazim or 0.2% propineb (Jamadar et al. 2011). The standard production practices already employed in well-managed Australian pomegranate orchards such as the use of certified planting material, monitoring crop health, orchard sanitation (AgriFutures Australia 2017b) could be used to control *E. punicae.*
Domestic trade	C – Minor significance at the local level

	The introduction of *E. punicae* into Australia would be expected to result in domestic movement restrictions on pomegranate fruit. The Australian pomegranate industry is focused on the domestic market and small-scale producers sell fruits to retailers or in local markets (AgriFutures Australia 2017b). Compliance with domestic biosecurity requirements would impose additional costs for producers, rendering part of existing and/or future interstate trade uneconomic. Given that the spread of the fungus between regions primarily occurs through infected planting material, restrictions on movement and trade of pomegranate planting material between production areas may be required.
International trade	C – Minor significance at the local level *E. punicae* is not currently regulated by Australia's trading partners on pomegranate fruit or nursery stock exports. Australia currently has export market access for pomegranate fruit to Fiji, Indonesia, Nauru, Papua New Guinea, Qatar, Singapore Tonga and United Arab Emirates. If established, trading partners may review their phytosanitary requirements on pomegranate, including the possibility of suspending or stopping trade and/or impose additional measures. Existing market access would need to be re-established and opening of new markets would be difficult. This would threaten economic viability.
Non-commercial and environmental	A – Indiscernible at the local level There are currently no known direct consequences of *E. punicae* on the environment. Chemical application to control the disease could affect the environment, but it is not expected to have any greater effect than the present use of agrochemicals. Indirect effects on native plants from fungicide applications are also expected to have indiscernible consequences.

4.12.6 Unrestricted risk estimate

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

Unrestricted risk estimate for *Elsinoë punicae*	
Overall likelihood of entry, establishment and spread	Very Low
Consequences	Low
Unrestricted risk	Negligible

As indicated, the unrestricted risk estimate for *E. punicae* has been assessed as 'Negligible', which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for *Elsinoë punicae* on this pathway.

4.13 Pest risk assessment conclusions

Table 4.7 Summary of unrestricted risk estimates for quarantine pests associated with pomegranate whole fruit and processed arils from India

Pest name	Likelihood of						Consequences	URE
	Entry			Establishment	Spread	EES		
	Importation	Distribution	**Overall**					
			Pomegranate whole fruit and processed arils pathways					
Fruit flies [Diptera: Tephritidae]								
Bactrocera carambolae (EP)								
Whole fruit pathway	High	High	**High**	High	High	High	High	**High**
Processed arils pathway	Moderate	High	**Moderate**	High	High	Moderate	High	**High**
Bactrocera dorsalis (EP)								
Whole fruit pathway	High	High	**High**	High	High	High	High	**High**
Processed arils pathway	Moderate	High	**Moderate**	High	High	Moderate	High	**High**
Bactrocera zonata (EP)								
Whole fruit pathway	High	High	**High**	High	High	High	High	**High**
Processed arils pathway	Moderate	High	**Moderate**	High	High	Moderate	High	**High**
Fruit borers [Lepidoptera: Lycaenidae]								
Deudorix epijarbas (EP, WA)								
Whole fruit pathway	Moderate	Moderate	**Low**	High	High	Low	Low	**Very Low**
Processed arils pathway	Low	Very Low	**Very Low**	High	High	Very Low	Low	**Negligible**
Deudorix isocrates								
Whole fruit pathway	Moderate	Moderate	**Low**	High	High	Low	Low	**Very Low**
Processed arils pathway	Low	Very Low	**Very Low**	High	High	Very Low	Low	**Negligible**
			Pomegranate whole fruit pathway					
Aphid [Hemiptera: Aphididae]								
Aphis punicae	Moderate	Moderate	**Low**	Moderate	High	Low	Low	**Very Low**
Scale insect [Hemiptera: Monophlebidae]								
Drosicha dalbergiae	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**

Pest name	Likelihood of						Consequences	URE
	Entry			Establishment	Spread	EES		
	Importation	Distribution	**Overall**					
Mites [Trombidiformes: Tenuipalpidae]								
Tenuipalpus granati	Moderate	Moderate	**Low**	High	Moderate	Low	Moderate	**Low**
Tenuipalpus punicae	Moderate	Moderate	**Low**	High	Moderate	Low	Moderate	**Low**
Thrips [Thysanoptera: Thripidae]								
Frankliniella occidentalis (GP, NT, RA)	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**
Scirtothrips dorsalis (GP, RA)	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**
Scirtothrips oligochaetus (GP)	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**
Mealybugs [Hemiptera: Pseudococcidae]								
Dysmicoccus neobrevipes (GP)	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**
Paracoccus marginatus (GP)	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**
Planococcus ficus (GP)	High	Moderate	**Moderate**	High	High	Moderate	Low	**Low**
Moths [Lepidoptera: Pyralidae]								
Cryptoblabes gnidiella (EP)	Low	Low	**Very Low**	High	High	Very Low	Moderate	**Very Low**
Bacterium [Xanthomonadales: Xanthomonadaceae]								
Xanthomonas axonopodis pv. *punicae*	Moderate	Low	**Low**	Moderate	Moderate	Low	Moderate	**Low**
Fungi								
Pseudocercospora punicae	Low	Low	**Very Low**	Moderate	Moderate	Very Low	Low	**Negligible**
Coleophoma empetri	Very Low	Low	**Very Low**	High	High	Very Low	Very Low	**Negligible**
Elsinoë punicae	Low	Very Low	**Very Low**	Moderate	Low	Very Low	Low	**Negligible**

EP: Species has been assessed previously and import policy already exists. **GP:** Species has been assessed previously in a Group PRA (thrips and mealybug Group PRA) and the Group PRA has been applied. **WA:** Pest of biosecurity concern for Western Australia. **NT**: Pest of biosecurity concern for the Northern Territory. **EES:** Overall likelihood of entry, establishment and spread. **URE:** Unrestricted risk estimate. This is expressed in an ascending scale from negligible to extreme. **RA:** regulated article, refer to section 4.6 for definition of a regulated article.

4.14 Summary of assessment of quarantine pests of concern

This section provides a summary of the assessment of quarantine pests and regulated articles of biosecurity concern as also shown in Figure 10.

4.14.1 Pomegranate whole fruit pathway

The pest categorisation process (Appendix A-1: Initiation and categorisation of pest of whole pomegranate fruit from India) identified 228 pests on the pomegranate whole fruit pathway. Of these 228 pests:

- 118 pests are already present in Australia, and not under official control, and therefore were not considered further;
- 88 of the remaining 110 pests were assessed as not having potential to be on the pomegranate whole fruit pathway, and therefore were not considered further.
- 2 of the remaining 22 pests were assessed not having the potential to establish and spread in Australia, and therefore was not considered further.

The outcome of the above process left 20 pests that required further consideration, in the form of a pest risk assessment. Pest risk assessments for these 20 pests were completed, with outcomes as described below.

- The estimated unrestricted risks for seven pests were assessed as achieving the ALOP for Australia. Therefore, no specific risk management measures are required for those pests on this pathway. These pests are:
  - Cornelian butterfly (*Deudorix epijarbas*)
  - Pomegranate butterfly (*Deudorix isocrates*)
  - Pomegranate aphid (*Aphis punicae*)
  - Honeydew moth (*Cryptoblabes gnidiella*)
  - Cercospora fruit spot (*Pseudocercospora punicae*)
  - Ripe rot (*Coleophoma empetri*)
  - Pomegranate scab (*Elsinoë punicae*)
- The estimated unrestricted risks for 13 pests were assessed as not achieving the ALOP for Australia, and thus specific risk management measures are required for these pests on this this pathway. These pests are:
  - Carambola fruit fly (*Bactrocera carambolae*)
  - Oriental fruit fly (*Bactrocera dorsalis*)
  - Peach fruit fly (*Bactrocera zonata*)
  - Almond mealybug (*Drosicha dalbergiae*)
  - Pomegranate mite (*Tenuipalpus granati*)
  - Pomegranate false spider mite (*Tenuipalpus punicae*)
  - Western flower thrips (*Frankliniella occidentalis*)
  - Chilli thrips (*Scirtothrips dorsalis*)
  - Mangosteen thrips (*Scirtothrips oligochaetus*)
  - Annona mealybug (*Dysmicoccus neobrevipes*)
  - Papaya mealybug (*Paracoccus marginatus*)
  - Vine mealybug (*Planococcus ficus*)

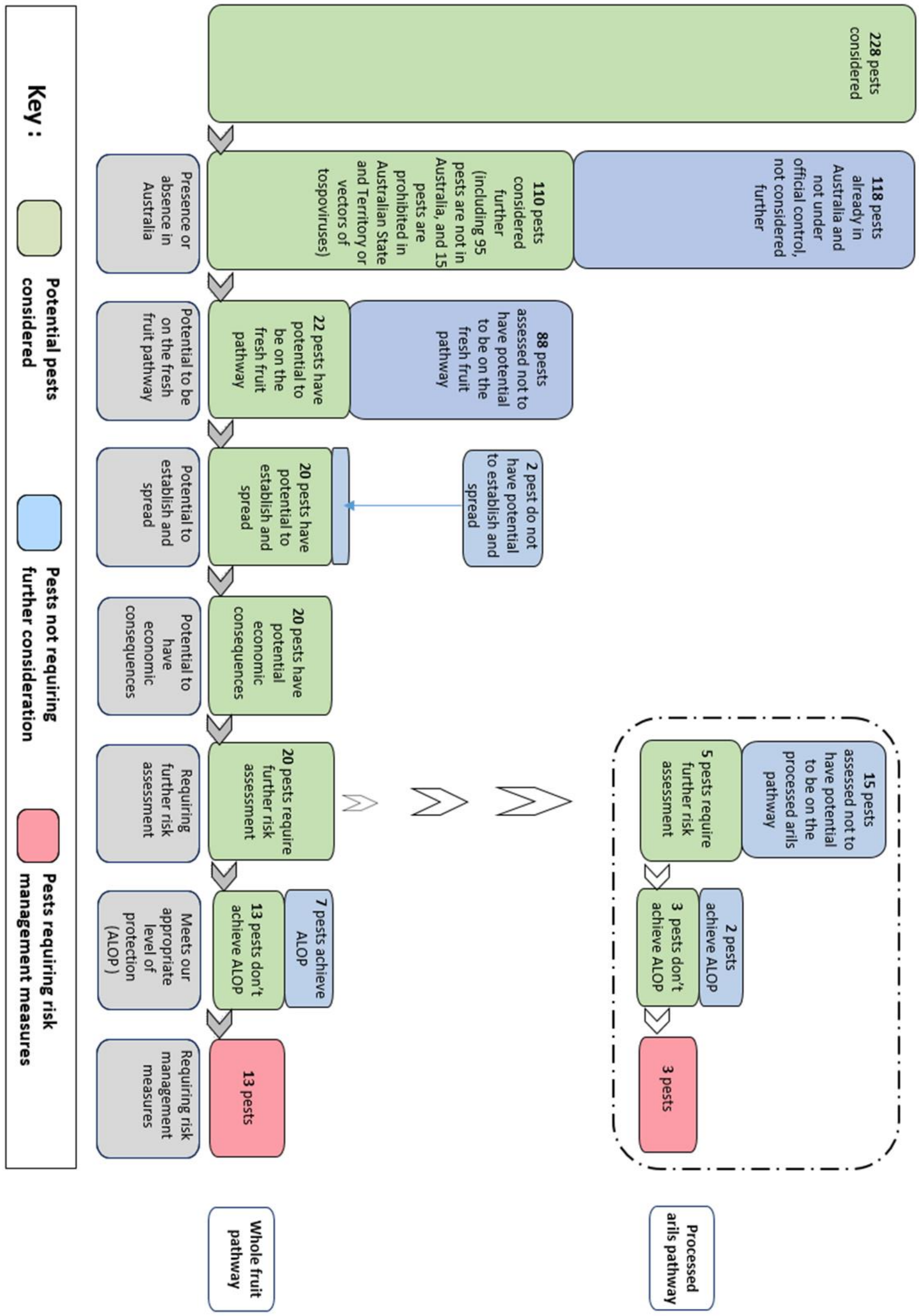
- Bacterial blight of pomegranate (*Xanthomonas axonopodis* pv. *punicae*)

4.14.2 Pomegranate processed arils pathway

The pest categorisation process for the processed arils pathway considered those 20 pests that were identified as requiring further assessment for the pomegranate whole fruit pathway. These pests were assessed for their potential presence on the processed arils pathway (Appendix A-2: Pests of pomegranate fruit that are assessed for pomegranate arils from India for human consumption). This approach was adopted because arils are a part of the whole fruit, and only those pests associated with whole fruit are considered to have the possibility of being on the processed arils pathway.

- Of the 20 pests considered, 15 pests were assessed as not having potential to be on the processed arils pathway, and therefore were not considered further.
- 5 pests required further consideration, in the form of a pest risk assessment. The estimated unrestricted risks for two pests were assessed as achieving the ALOP for Australia. Therefore, no specific risk management measures are required for these pests on this pathway. These pests are:
  - Cornelian butterfly (*Deudorix epijarbas*)
  - Pomegranate butterfly (*Deudorix isocrates*).
- The estimated unrestricted risks for three fruit flies were assessed as not achieving the ALOP for Australia, and thus specific risk management measures are required for these pests on this pathway. These pests are:
  - Carambola fruit fly (*Bactrocera carambolae*)
  - Oriental fruit fly (*Bactrocera dorsalis*)
  - Peach fruit fly (*Bactrocera zonata*).

Figure 10 Summary of assessment of quarantine pests of concern on the pomegranate whole fruit and processed arils from India pathway



5 Pest risk management

This chapter provides information on the management of quarantine pests and regulated thrips identified as having an unrestricted risk that does not achieve the appropriate level of protection (ALOP) for Australia. The recommended risk management measures for these pests are described in this chapter. This chapter also describes the operational system that is required for the maintenance and verification of the phytosanitary status of pomegranate whole fruit and processed arils from India for export to Australia.

5.1 Pest risk management measures and phytosanitary procedures

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests and regulated thrips for Australia, where they have been assessed to have an unrestricted risk that does not achieve the ALOP for Australia. In calculating the unrestricted risk estimate, the standard commercial production and processing practices for pomegranate whole fruit and processed arils in India, have been considered, as have post-harvest procedures and the packing of pomegranate whole fruit and processed arils (as described in Chapter 3: India's commercial practices for pomegranate whole fruit and processed arils).

Pest risk management measures identified for quarantine thrips are considered appropriate for the regulated thrips.

In addition to India's standard commercial production systems and packing house practices for pomegranate whole fruit and processed arils (as described in Chapter 3: India's commercial practices for pomegranate whole fruit and processed arils), specific pest risk management measures are recommended in order to achieve the ALOP for Australia.

In this chapter, the department recommends risk management measures that may be applied to consignments of pomegranate whole fruit and processed arils sourced from India. Finalisation of the import conditions may be undertaken with input from the Australian states and territories as appropriate.

5.1.1 Analysis of pest interception data from 2012 to 2018

Australia imported 11,186 tonnes of pomegranate whole fruit from the USA from 2012 to 2018. Although Australia also currently permits the importation of pomegranate from New Zealand, no imports of this commodity from New Zealand have occurred during this period.

This pest risk analysis identified 13 pests as requiring specific risk management measures, two of which are pests of regional concern. Examination of interception data collected from inspections of imports of pomegranate from the USA found records of thrips, mites, mealybugs, scales and lepidopteran pests on pomegranate whole fruit. All of those organisms intercepted are actioned under existing conditions for importing pomegranate fruit from the USA. These conditions required that the department undertakes an assessment to determine the quarantine status of these organisms, and take phytosanitary actions as appropriate.

The continual interception of arthropod pests on pomegranates imported from the USA resulted in a change to the import requirements. As of 1 August 2019, the department requires the management measure of pre-export methyl bromide fumigation of pomegranate whole fruit, imported into Australia from the USA to manage the risk of arthropod pests.

Additionally, there have been detections of fruit fly pests that are of biosecurity concern to Australia in processed arils imported from India and Peru into the USA. This indicates that arils can provide a pathway for fruit flies.

5.1.2 Pest risk management for quarantine pests of pomegranate whole fruit and processed arils from India

The pest risk assessment process identified the quarantine pests listed in Table 5.1 as having unrestricted risks that do not achieve the ALOP for Australia. Therefore, risk management measures are recommended to manage the risks posed by these pests. The recommended measures are listed in Table 5.1, and further discussed in Section 5.1.3.

Table 5.1 Risk management measures recommended for quarantine pests and regulated thrips associated with pomegranate whole fruit and processed arils from India

Pest	Common name	Measures	
		Whole fruit	Processed arils
Fruit flies			
Bactrocera carambolae (EP)	Carambola fruit fly	Area freedom **b** OR Fruit treatment considered to be effective against all life stages of this fruit fly species	Area freedom **b** OR Systems approach OR Fruit treatment considered to be effective against all life stages of this fruit fly species
Bactrocera dorsalis (EP)	Oriental fruit fly	Area freedom **b** OR Fruit treatment considered to be effective against all life stages of this fruit fly species	Area freedom **b** OR Systems approach OR Fruit treatment considered to be effective against all life stages of this fruit fly species
Bactrocera zonata (EP)	Peach fruit fly	Area freedom **b** OR Fruit treatment considered to be effective against all life stages of this fruit fly species	Area freedom **b** OR Systems approach OR Fruit treatment considered to be effective against all life stages of this fruit fly species
Scale insect			
Drosicha dalbergiae	Almond mealybug	Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action **a**	Not applicable
Mites			
Tenuipalpus granati	Pomegranate mite	Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action **a**	Not applicable
Tenuipalpus punicae	False spider mite	Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action **a**	Not applicable
Thrips			
Frankliniella occidentalis (GP, RA, NT)	Western flower thrips	Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action **a**	Not applicable
Scirtothrips dorsalis (GP, RA)	Chilli thrips	Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action **a**	Not applicable

Scirtothrips oligochaetus (GP)	Mangosteen thrips	Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action **a**	Not applicable
Mealybugs			
Dysmicoccus neobrevipes (GP)	Grey pineapple mealybug	Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action **a**	Not applicable
Paracoccus marginatus (GP)	Papaya mealybug	Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action **a**	Not applicable
Planococcus ficus (GP)	Vine mealybug	Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action **a**	Not applicable
Bacterium			
Xanthomonas axonopodis pv. *punicae*	Bacterial blight of pomegranate	Area freedom **b** OR Systems approach	Not applicable

a Remedial action (by DAC) may include applying approved treatment to the consignment to ensure that the pest is no longer viable or withdrawing the consignment from export to Australia. **b** Area freedom may include pest free areas, pest free places of production or pest free production sites. **EP**: Species has been assessed previously and import policy already exists. **GP**: Species has been assessed previously in a Group PRA and the Group PRA is applied. **RA:** regulated article, refer to Section 4.6 for definition of a regulated article. **NT:** Pest of biosecurity concern for Northern Territory.

5.1.3 Risk management measures for quarantine pests and regulated thrips associated with pomegranate whole fruit and processed arils

This final report for fresh pomegranate whole fruit and processed arils recommends that when the following risk management measures are followed, the restricted risk for all quarantine and regulated pests assessed will achieve the ALOP for Australia. The management measures are:

For whole pomegranate fruit

- area freedom or fruit treatment (such as cold treatment or irradiation) for fruit flies.
- appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action for the scale insect, mites, thrips, and mealybug pests.
- area freedom or a systems approach approved by the department for the bacterium.

For processed arils

- area freedom or a systems approach approved by the department or a fruit treatment (such as irradiation) for fruit flies.

Management for fruit flies for pomegranate whole fruit and processed arils

To manage the risk of *Bactrocera carambolae, B. dorsalis* and *B. zonata*, the department recommends the management measures of area freedom or fruit treatments known to be effective against all life stages of the pest (such as cold treatment or irradiation). The objective of this measure is to reduce the risks associated with these pests to achieve the ALOP for Australia.

Recommended measure 1: Area freedom for pomegranate whole fruit and processed arils

If area freedom from *B. carambolae, B. dorsalis* and *B. zonata* can be demonstrated for a pomegranate production area, the likelihood of importation of the pest species with pomegranate whole fruit sourced from this area, and with arils produced from these fruits, will be reduced to a level that would achieve the ALOP for Australia.

The requirements for establishing and maintaining pest free areas or pest free places of production are set out in ISPM 4: *Requirements for the establishment of pest free areas* (FAO 2017a) and ISPM 10: *Requirements for the establishment of pest free places of production and pest free production sites* (FAO 2016b), and more specifically for fruit flies, in ISPM 26: *Establishment of pest free areas for fruit flies (Tephritidae)* (FAO 2019f).

Under the area freedom option, monitoring and trapping of fruit flies in the specified pomegranate export orchards and packing houses of India would be required. DAC would be required to notify the detection of any fruit fly species of economic importance in the region within 48 hours. The Department of Agriculture, Water and the Environment would then assess the species and number of individual flies detected and the circumstances of the detection, before advising DAC of any action to be taken. If fruit flies are detected at offshore pre-shipment inspection by DAC or on-arrival inspection, trade would be suspended immediately, pending the outcome of an investigation.

Should India wish to use area freedom as a measure to manage the risk posed by *Bactrocera carambolae, B. dorsalis* and *B. zonata,* DAC will be required to provide a submission to the department for its consideration. The submission must fulfil requirements as set out in ISPM 4 (FAO 2017a), ISPM 10 (FAO 2016b) and ISPM 26 (FAO 2019f) and will be subject to approval by the department.

For pomegranate whole fruit and/or processed arils sourced from outside recognised fruit fly pest free areas, treatment known to be effective against all life stages of *B. carambolae, B. dorsalis* and *B. zonata*, for example, cold disinfestation treatment or irradiation, must be undertaken.

Recommended measure 2: Irradiation for pomegranate whole fruit and processed arils

Currently, irradiated pomegranate whole fruit or processed arils are not permitted to be sold in Australia under regulations managed by Food Standards Australia New Zealand (FSANZ). However, an application has been made to FSANZ to amend the Food Standards Code (Standard 1.5.3) to include irradiation as a phytosanitary measure for all fruits and vegetables, including pomegranate, to be sold in Australia. Information on the irradiation of food, and examples of previous FSANZ assessments, can be found on the FSANZ website (foodstandards.gov.au).

Irradiation treatment is considered a suitable measure for *B. carambolae, B. dorsalis* and *B. zonata*, applied as a treatment of 150 gray minimum absorbed dose, consistent with ISPM 28 Annex 7*: Irradiation treatment for fruit flies of the family Tephritidae (generic)* (FAO 2017b). The use of irradiation as a phytosanitary measure is subject to approval by the Department of Agriculture, Water and the Environment of the irradiation facilities identified by DAC. Should India wish to use irradiation as a phytosanitary measure, DAC would need to provide a submission to the department for its consideration. The submission would be required to fulfil the requirements as set out in ISPM 18 (FAO 2016c).

Recommended measure 3: Cold treatment for pomegranate whole fruit

The department considers that certain cold treatments would effectively manage the risk of *B. carambolae, B. dorsalis* and *B. zonata* on pomegranate whole fruit from India.

The department recommends the following specifications for temperatures and exposure times where cold disinfestation treatment is utilised for *B. carambolae, B. dorsalis* and *B. zonata*. The treatments for *B. carambolae* and *B. dorsalis* are based on the USDA treatment manual (USDA T107-a) for *Ceratitis capitata* in pomegranate whole fruit.

The treatment for *B. zonata* is based on the USDA treatment manual (USDA T107-L) for *B. zonata* in orange (*Citrus sinensis*) fruit, as there are no published data available on suitable temperature and duration combination specific to management of the biosecurity risk of *B. zonata* on pomegranate fruit.

Treatment schedule for *B. carambolae* and *B. dorsalis*:

- fruit held at 1.11°C or below for 14 days, or
- fruit held at 1.67°C or below for 16 days, or
- fruit held at 2.22°C or below for 18 days.

Treatment schedule for *B. zonata*:

- fruit held at 1.67°C or below for 18 days.

If the cold treatment is to be applied for either *B. carambolae* and/or *B. dorsalis* present with *B. zonata*, then the treatment recommended for *B. zonata* (i.e. 1.67°C or below for 18 days) must be adopted.

Cold treatment may be conducted pre-export in India or in transit. Both pre-shipment and in-transit cold disinfestation treatments must fulfil the requirements as set out in the Australian phytosanitary treatment application standard for cold disinfestation treatment (Department of Agriculture and Water Resources 2017).

Australia has current policy for cold disinfestation treatment of fruit flies for various commodities, including cold disinfestation treatment for *B. zonata* in citrus from Egypt (Biosecurity Australia 2002) and *B. dorsalis* in table grapes from India (Department of Agriculture 2015) and longans and lychees from China (DAFF 2004a).

A study by Myers et al. (2016) comparing the cold tolerance of six *Bactrocera* species found that the species responded to cold treatment in a similar manner. (Hallman et al. 2013) found that *B. invadens* (now synonymised with *B. dorsalis*) was less cold tolerant than *C. capitata*. However, the authors could not conclude that *B. zonata* is not more cold tolerant than *C. capitata*. Since *B. carambolae* and *B. dorsalis* are reported to have relatively similar cold tolerances (Myers et al. 2016), and to be slightly less cold tolerant than *C. capitata*, cold disinfestation treatment as presented in the USDA treatment manual (USDA T107-a) for *C. capitata* on pomegranate is considered appropriate for *B. carambolae* and *B. dorsalis*. However, because it could not be concluded that *B. zonata* is not more cold tolerant than *C. capitata*, and there is no cold treatment data available that is specific to *B. zonata* on pomegranate, the cold disinfestation treatment as presented in the USDA treatment manual (USDA T107-L) for *B. zonata* on orange is adopted for *B. zonata* on pomegranate from India.

Should India wish to use cold treatment as a measure, DAC will need to demonstrate that its application will meet the requirements of the Australian phytosanitary treatment application standard for cold disinfestation treatment. If pre-shipment cold treatment is to be used, the Indian NPPO will need to provide a submission to the department that demonstrates that a facility can apply the treatment accurately and consistently.

Recommended measure 4: Systems approach for processed arils

A systems approach integrates different risk management measures, at least two of which act independently, which cumulatively achieve the required level of phytosanitary protection. The requirements of a systems approach are set out in ISPM 14: *The use of integrated measures in a systems approach for pest risk management* (FAO 2019d), and more specifically for fruit flies, in ISPM 35: *Systems approach for pest risk management of fruit flies (Tephritidae)* (FAO 2019f).

The department considers a systems approach could be used to reduce the risk of *Bactrocera carambolae, B. dorsalis* and/or *B. zonata* being imported to Australia with consignments of processed arils. A systems approach could be based on a combination of production site preventative measures, monitoring, and pest control, with application of post-harvest measures, including processing and inspection.

Should India wish to use a systems approach as a measure to manage the risk posed by these fruit fly pests, DAC would need to submit a proposal to the department for consideration. The proposal would need to outline all components of the system and how these components would address the risks posed by fruit flies.

Management for bacterial blight for pomegranate whole fruit

The department recommends area freedom or use of a systems approach as measures for *X. axonopodis* pv. *punicae*. The objective of the proposed measures is to reduce the risk associated with this pathogen to achieve the ALOP for Australia.

Recommended measure 1: Area freedom for bacterial blight of pomegranate whole fruit

Should India wish to use area freedom as a measure to manage the risk posed by this pathogen, DAC would need to provide the department with a submission demonstrating area freedom for its consideration.

Recommended measure 2: Systems approach for bacterial blight of pomegranate whole fruit

A systems approach integrates different risk management measures, at least two of which act independently, which cumulatively achieve the required level of phytosanitary protection. The requirements of a systems approach are set out in ISPM 14: *The use of integrated measures in a systems approach for pest risk management* (FAO 2019d).

The department considers a systems approach could be used to reduce the risk of *X. axonopodis* pv. *punicae* being imported to Australia with consignments of pomegranate whole fruit. A systems approach could be based on a combination of production site preventative measures, monitoring, and pest control, with application of post-harvest measures.

Should India wish to use a systems approach as a measure to manage the risk posed by this pathogen, DAC would need to submit a proposal to the department for consideration. The proposal would need to outline all components of the system and how these components would address the risks posed by the pathogen.

Management for pomegranate whole fruit for scale insect, mites (pomegranate mite and pomegranate false spider mite), quarantine thrips (*Scirtothrips oligochaetus*), regulated thrips (*Frankliniella occidentalis* (NT) and *Scirtothrips dorsalis*) and mealybugs (*Dysmicoccus neobrevipes, Paracoccus marginatus* and *Planococcus ficus*).

Recommended measure 1: Appropriate packing house practices combined with pre-export visual inspection and, if found, remedial action for pomegranate whole fruit.

The department recommends that risk-mitigating packing house practices of fruit cleaning, which include washing and brushing to ensure the calyx is appropriately cleaned, combined with pre-export visual inspection and, if found, remedial action, would be appropriate to manage the risk of the following pests being imported to Australia with consignments of pomegranate whole fruit: scale insect (*Drosicha dalbergiae*), mites (*Tenuipalpus granati* and *T. punicae*), quarantine thrips (*Scirtothrips oligochaetus*), regulated thrips (*Frankliniella occidentalis* (NT) and *Scirtothrips dorsalis*), and quarantine mealybugs (*Dysmicoccus neobrevipes, Paracoccus marginatus* and *Planococcus ficus*). The objective of this combined measure is to reduce the risk associated with these pests to achieve the ALOP for Australia.

The appropriate packing house practice of fruit cleaning will also remove debris and stamen clusters, leaving a clean calyx, which will reduce the possibility of external arthropod pests being present in the fruit calyx and reduce the likelihood that any pest remains undetected.

All consignments of pomegranate whole fruit exported to Australia from India must be inspected by technical officers from DAC, and found free of quarantine thrips, regulated thrips, mealybugs, scale insects and mites. Pre-export visual inspection must be undertaken by technical officers from DAC in accordance with ISPM 23: *Guidelines for inspection* (FAO 2019e) and be consistent with the principles of ISPM 31: *Methodologies for sampling of consignments* (FAO 2016d). Export consignments found to contain any quarantine thrips, regulated thrips, quarantine mealybugs, scale insects or mites will be subject to remedial action. Remedial action may include withdrawing the consignment from export to Australia or, if available, applying an approved treatment to the consignment to ensure that the pest is no longer viable.

5.1.4 Consideration of alternative measures

Consistent with the principle of equivalence detailed in ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2019c), the department will consider any alternative measure proposed by DAC, providing that it demonstrably manages the target pests to achieve the ALOP for Australia. Evaluation of any such measure will require a technical submission from DAC that details the proposed measure, including suitable information to support the claimed efficacy, for consideration by the department.

5.2 Operational system for the maintenance and verification of phytosanitary status

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

5.2.1 A system of traceability to production sites

The objectives of the recommended requirement are to ensure that:

- pomegranate whole fruit and processed arils are sourced only from production sites producing commercial export quality fruit
- production sites from which pomegranates are sourced can be identified so that investigation and corrective action can be targeted, rather than applied to all contributing export farms, in the event that live/viable pests are intercepted
- production sites are capable of applying in-field measures (for example, pest free production site).

Export production sites are registered with DAC before commencement of harvest each season. The list of registered production sites must be kept by DAC. DAC must ensure that pomegranate whole fruit and processed arils for export to Australia can be traced back to the production site. DAC is required to ensure the registered production sites are suitably equipped and have a system in place to carry out the specified phytosanitary activities. Records of DAC audits must be made available to the Department of Agriculture, Water and the Environment upon request. Records of production site monitoring/management must be made available upon request.

5.2.2 Registration of packing houses and auditing of procedures

The objectives of this recommended procedure are to ensure that:

- pomegranate whole fruit and processed arils are sourced only from packing houses processing commercial-quality pomegranate whole fruit and processed arils that have been approved by DAC.

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

5.2.3 Registration of treatment providers and auditing of procedures

The objectives of this recommended procedure are to ensure that:

- pomegranate whole fruit or arils are treated by treatment providers that have been approved by DAC.

In circumstances where pomegranate whole fruit or processed arils undergo treatment prior to export, this process must be undertaken by the treatment providers that have been registered with and audited by DAC for that purpose. Records of DAC registration requirements and audits must be made available to the Department of Agriculture, Water and the Environment upon request.

Approval for treatment providers by DAC must include verification that suitable systems are in place to ensure compliance with the treatment requirements. These may include:

- documented procedures to ensure pomegranate whole fruit and processed arils are appropriately treated, and safeguarded post-treatment
- staff training to ensure compliance with procedures
- record keeping procedures
- suitability of facilities and equipment compliance with DAC's system of oversight of treatment application or system of authorisation of treatment oversight.
- compliance with international standards, and where specified by the department, Australian standards.

The Australian NPPO provides final approval of facilities, following review of the regulatory oversight provided by the exporting NPPO and the capability demonstrated by the facility. Site visits may be required for the Australian NPPO to have assurance that the treatment can be applied accurately and consistently.

The use of irradiation requires a shared work plan that documents roles and responsibilities of all relevant stakeholders.

5.2.4 Packaging, labelling and containers

The objectives of this recommended procedure are to ensure that:

- Pomegranate whole fruit and processed arils intended for export to Australia, and all associated packaging, are not contaminated by quarantine pests or regulated articles (defined in ISPM 5: *Glossary of phytosanitary terms*) (FAO 2019b).
- unprocessed packaging material is not permitted as it may vector other pests not associated with pomegranate whole fruit and processed arils.
- all wood material associated with the consignment used in packaging and transport of fresh whole pomegranate or processed arils must comply with the department's import conditions, as published on BICON.
- secure packaging is used for export of fresh pomegranate whole fruit or processed arils to Australia to prevent re-infestation during storage and transport and prevent escape of pests during clearance procedures on-arrival in Australia. To make consignments insect-proof and secure, at least one of the following packaging options must be used:

  - **Integral cartons** – produce may be packed in integral (fully enclosed) cartons (packages) with boxes having no ventilation holes and lids tightly fixed to the bases.

  - **Ventilation holes of cartons covered** – cartons (packages) with ventilation holes must have the holes covered/sealed with a mesh/screen of no more than 1.6mm pore size and not less than 0.16mm strand thickness. Alternatively, the vent holes could be taped over.

  - **Polythene liners** – vented cartons (packages) with sealed polythene liners/bags within are acceptable (folded polythene bags are acceptable).

  - **meshed or shrink wrapped pallets or Unit Load Devices (ULDs)** – ULDs transporting cartons with open ventilation holes/gaps, or palletised cartons with ventilation holes/gaps must be fully covered or wrapped with polythene/plastic/foil sheet or mesh/screen of no more than 1.6mm diameter pore size. The wrapped pallet or ULD must be loaded and sealed at packing house or treatment facility.

– **produce transported in sealed fully enclosed containers** – cartons (packages) with holes as loose boxes or on pallets may be transported in fully enclosed containers. Enclosed containers include six-sided container with solid sides, or ULDS with tarpaulin sides that have no holes or gaps. The container must be loaded and sealed at packing house or treatment facility.

- the packaged pomegranate whole fruits and processed arils are labelled with sufficient identification information for the purposes of traceability. This may include:

  – for treated product: the treatment facility name/number and treatment identification number.

  – for pomegranate whole fruit and processed arils where the measures include area freedom/systems approach: the orchard and packing house number.

  – for pomegranate where any phytosanitary measure is applied at the packing house: the packing house registration reference/number.

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

5.2.5 Specific conditions for storage and movement

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

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

5.2.6 Freedom from trash

The objective of this recommended measure is to ensure that pomegranate whole fruit and processed arils for export are free from trash (for example, loose stem and leaf material, seeds, soil, animal matter/parts or other extraneous material) and foreign matter.

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

5.2.7 Pre-export phytosanitary inspection and certification by DAC

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

- All consignments must be inspected in accordance with official procedures for all visually detectable quarantine pests and other regulated articles (including soil, animal and plant debris) at a standard 600 unit sampling rate per phytosanitary certificate, or equivalent (as defined in ISPM 31: *Methodologies for sampling consignments* (FAO 2016d)). One unit is considered to be a single pomegranate fruit or a single pack of processed arils.
- The department may request information from DAC on the inspection method used to identify quarantine pests.
- A phytosanitary certificate must be issued for each consignment upon completion of pre-export inspection to verify that the required risk management measures have been undertaken prior to export and the consignment meets Australia's import requirements.
- Each phytosanitary certificate must include:
  - a description of the consignment (including traceability information)
  - details of disinfestation treatments (for example, cold treatment)
  - any other statements that may be required such as identification of the consignment as being sourced from a recognised pest free production site.

5.2.8 Phytosanitary inspection by the Department of Agriculture, Water and the Environment

The objectives of this recommended procedure are to ensure that:

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

On-arrival in Australia, the department will:

- assess documentation to verify that the consignment is as described on the phytosanitary certificate, that required phytosanitary actions have been undertaken, and that product security has been maintained.
- verify that the biosecurity status of consignments of pomegranate whole fruit and processed arils from India meet Australia's import conditions. When inspecting consignments, the department will use random samples of 600 units per phytosanitary certificate (or as goods are loaded) and inspection methods suitable for the commodity.

5.2.9 Remedial action(s) for non-compliance

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

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

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

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

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

5.3 Uncategorised pests

If an organism is found that has not been categorised, including a contaminant pest, on pomegranate whole fruit or processed arils either in India or on-arrival in Australia, it will require assessment by the department to determine its quarantine status and whether phytosanitary risk management action is required.

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

5.4 Review of processes

5.4.1 Verification of protocol

Prior to or during the first season of trade, the department will verify the implementation of the required import conditions and phytosanitary measures including registration, operational procedures and treatment providers, where applicable. For example, for measures conducted pre-export, the department may require information about standard operating procedures (SOPs). This may involve representatives from the department visiting areas in India that produce pomegranate whole fruit and/or processed arils for export to Australia.

5.4.2 Review of policy

DAC must inform the Department of Agriculture, Water and the Environment immediately on detection of any newly identified pests of pomegranate whole fruit or processed arils that might be of potential biosecurity concern to Australia, or when the phytosanitary status of a pest has changed, in accordance with ISPM 8: *Determination of pest status in an area* (FAO 2016a).

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

5.5 Meeting Australia's food laws

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

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

Currently pomegranate arils are surveillance foods and referred for inspection and testing at the rate of 5%. If referred for inspection, processed arils will be subject to a visual inspection and label check and samples will be taken for a fruit and vegetable residue screen.

Food Standards Australia New Zealand (FSANZ) is responsible for developing and maintaining the Code, including Standard 1.4.2–Agvet chemicals. This standard is available on the Federal Register of Legislation Federal Register of Legislation or through the FSANZ website

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

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

In the future, importers of certain foods will also need to provide evidence that through-chain controls are in place to manage any food safety hazards associated with the production and processing of the food. This evidence will need to be in the form of a ‘Food safety management certificate’. The legislation to support this change is still being finalised. However, it is expected to be implemented in 2020.

The department, in consultation with FSANZ, will determine what foods require ‘Food safety management certificates’ based on:

- evidence of their association with causing food-borne illness.
- evidence that through-chain controls to demonstrate identified food safety hazards have been effectively managed.
- assessment of border testing alone being insufficient to provide assurance of the food’s safety.

The foods requiring ‘Food safety management certificates’ will be listed in the Imported Food Control Order 2001. While these foods have yet to be listed, they are expected to include horticulture imports identified by FSANZ as posing a medium to high risk to public health. These are likely to be:

- ‘ready-to-eat’ raw or minimally processed produce associated with foodborne disease such as fresh and frozen berries, pomegranate arils, bagged leafy greens, cut packaged fruit, melons, sprouted seeds, and fresh herbs.
- ‘ready-to-eat’ raw or minimally processed nuts (shelled and unroasted).

To be accepted, the 'Food safety management certificate' will need to be a recognised government certificate or a non-government certificate recognised under the Global Food Safety Initiative (GFSI) or a National Accreditation Body under the International Accreditation Forum. The GFSI recognises food safety certification programmes to defined requirements in its benchmarking requirements. National Accreditation Bodies accredit Certification Bodies. Certification bodies certify companies against internationally recognised standards, including those covering food safety management systems.

Updates on food safety management certificates and other changes to imported food safety requirements can be obtained by subscribing to imported food notices on the department website (https://www.agriculture.gov.au/import/goods/food/notices)-

6 Conclusion

The findings of this final risk analysis for pomegranate whole fruit and processed arils from India are based on a comprehensive scientific analysis of relevant literature, and other avenues of enquiry.

The department considers that the risk management measures recommended in this report will provide an appropriate level of protection against the quarantine pests and regulated thrips identified as potentially associated with the trade of fresh pomegranate whole fruit and processed arils from India.

Appendix A-1: Initiation and categorisation for pests of pomegranate whole fruit from India

The table identifies pests that have the potential to be present on pomegranate whole fruit grown in India and arils produced from these fruit using commercial production and packing procedures to be imported into Australia.

The purpose of pest categorisation is to ascertain which of these pests require detailed assessment in order to determine whether phytosanitary measures are appropriate. The steps in the pest categorisation process are considered sequentially. The assessment terminates at 'Yes' for the third column (present within Australia), except for pests that are present but under official control, and/or are pests of regional concern. In cases where this does not apply, assessment terminates at the first 'No' in any of the following columns.

In the final column of the table (column 7) the acronyms 'EP', 'NT' and 'WA' are used. The acronym EP (existing policy) is used for pests that have previously been assessed by Australia and for which import policy exists. The acronyms NT and WA are used to identify organisms that have been recorded in some regions of Australia but, due to interstate quarantine regulations, are considered pests of regional concern to Northern Territory and Western Australia respectively.

The *Final group pest risk analysis for thrips and tospoviruses on fresh fruit, vegetable, cut-flower and foliage imports* (Australian Government Department of Agriculture and Water Resources 2017) and the Final group pest risk analysis for mealybugs and viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports (Australian Government Department of Agriculture and Water Resources 2017) have been applied in this risk analysis. Application of group policy requires identification of three species of each relevant group associated with the commodity pathway. However, if any other quarantine pests or regulated articles not included in this risk analysis and/or in the relevant group policies is detected at pre-export or on-arrival in Australia, the relevant group policy will also apply.

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

For the purposes of pest categorisation, the table does not provide a comprehensive list of all species associated with the entire plant, but concentrates on pests that could be on the pomegranate whole fruit import pathway. References to soil-borne nematodes, soil-borne pathogens, and secondary pests have not been listed, as they are not directly related to the import pathway of pomegranate whole fruit and would be addressed by Australia's current approach to contaminating pests.

The department is aware of the recent changes in fungal nomenclature concerning the separate naming of different states of fungi with a pleomorphic life cycle. However, as the nomenclature for these fungi is in a phase of transition and many priorities of names are still to be resolved, this report uses the generally accepted names and provides alternatively used names as synonyms, where required. The department is also aware of the changes in nomenclature of arthropod species based on the latest morphological and molecular reviews. As official lists of accepted names become available, these names will be adopted.

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
ARTHROPODS						
ACARI (mites)						
Aceria granati Canestrini & Massalongo 1894 [Acari: Eriophyidae] (synonym: *Eriophyes granati* Canestrini & Massalongo 1894)	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Aceria granati*. This species is associated with pomegranate leaves (Lindquist, Sabelis & Bruin 1996).	Assessment not required	Assessment not required	No
Anystis baccarum Linnaeus 1758 [Acari: Anystidae]	Yes (Sharma & Agarwal 2007)	Yes (Halliday 1998; Holm & Wallace 1989)	Assessment not required	Assessment not required	Assessment not required	No
Brevipalpus lewisi McGregor 1949 [Acari: Tenuipalpidae]	Yes (Vacante & Kreiter 2018)	Yes (Vacante & Kreiter 2018)	Assessment not required	Assessment not required	Assessment not required	No
Brevipalpus phoenicis Geijskes 1936 [Acari: Tenuipalpidae]	Yes (Beard et al. 2015)	Yes (Halliday 1998; Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Cenopalpus pulcher Canestrini & Fanzago 1876 [Acari: Tenuipalpidae] Flat scarlet mite	Yes (Balikai, Kotikal & Prasanna 2009; Canestrini & Fanzago 2020; Menon, Ghai & Katiyar 1971)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Cenopalpus pulcher*. A majority of the literature on the status of this pest in India and its association with the pathway cite Balikai, Kotikal and Prasanna (2009), who quoted a publication dating back to 1975 (Nair 1975). However, there is no reliable report since then that reports as this pest is present on the pathway.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cheletogenes ornatus Canestrini & Fanzago 1876 [Acari: Cheyletidae]	Yes (Karmakar & Gupta 2011; Pal et al. 2004)	Yes (Halliday 1998)	Assessment not required	Assessment not required	Assessment not required	No
Eutetranychus orientalis Klein 1936 [Acari: Tetranychidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Walter, Halliday & Smith 1995)	Assessment not required	Assessment not required	Assessment not required	No
Glycyphagus domesticus De Geer 1778 [Acari: Glycyphagidae]	Yes (Gupta & Chaterjee 2004)	Yes (Halliday & Walter 2006)	Assessment not required	Assessment not required	Assessment not required	No
Oligonychus punicae Hirst 1926 [Acari: Tetranychidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Oligonychus punicae*. This species is associated with pomegranate leaves (Amini 2008).	Assessment not required	Assessment not required	No
Tenuipalpus granati Sayed 1946 [Acari: Tenuipalpidae] Pomegranate mite	Yes (Balikai, Kotikal & Prasanna 2009; Çobanoğlu, Ueckermann & Sağlam 2016)	Not known to occur	Yes: Pomegranate fruit provide a pathway for *Tenuipalpus granati*. This species is associated with pomegranate leaves, flowers and fruit (Ananda, Kotikal & Balikai 2009; Jeppson, Keifer & Baker 1975; USDA 2017).	Yes: *Tenuipalpus granati* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Jeppson, Keifer & Baker 1975). Tenuipalpidae mites may be able to access hosts in the environment via air currents (Childers & Rodrigues 2011; Pedgley 1982).	Yes: *Tenuipalpus granati* has the potential for economic consequences in Australia. This species is a pest of vineyards in Egypt (Jeppson, Keifer & Baker 1975; Yousef, Zaher & El-Hafiez 1980). The feeding of this species causes leaf mottling and necrosis, fruit blistering and deformation, and may reduce crop yield (Vacante & Gerson 2012).	Yes

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Tenuipalpus punicae Pritchard & Baker 1958 [Acari: Tenuipalpidae] Pomegranate false spider mite	Yes (Balikai, Kotikal & Prasanna 2009; Çobanoğlu, Ueckermann & Sağlam 2016)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Tenuipalpus punicae*. This species is associated with pomegranate leaves and fruit (Al-Gboory & El-Haidari 1988; Cocuzza et al. 2016; Holland, Hatib & Bar-Ya'akov 2009; Jeppson, Keifer & Baker 1975).	Yes: *Tenuipalpus punicae* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Cocuzza et al. 2016; Jeppson, Keifer & Baker 1975). Tenuipalpidae mites may be able to access hosts in the environment via air currents (Childers & Rodrigues 2011; Pedgley 1982).	Yes: *Tenuipalpus punicae* has the potential for economic consequences in Australia. This species causes yield loss and unmarketable fruit. Fruit damage on pomegranate trees in Iraq was reported to be as high as 58% (Al-Gboory & El-Haidari 1988). The feeding of this species causes leaf mottling and necrosis, fruit blistering and deformation, and may reduce crop yield (Vacante & Gerson 2012).	Yes
COLEOPTERA						
Anomala dimidiata Hope 1831 [Coleoptera: Scarabaeidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Anomala dimidiata*. This species is associated with pomegranate leaves (Jha & Sen-Sarma 2012).	Assessment not required	Assessment not required	No
Apate monachus Fabricius 1775 [Coleoptera: Bostrychidae]	Yes (Durai et al. 2017)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Apate monachus*. This species is associated with pomegranate trunks and branches (Bonsignore 2012).	Assessment not required	Assessment not required	No
Apogonia ferruginea Fabricius 1781 [Coleoptera: Scarabaeidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Apogonia ferruginea*. This species is associated with pomegranate leaves (Bhattacharyya et al. 2017).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Carpophilus dimidiatus Fabricius 1792 [Coleoptera: Nitidulidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Barrer 1983; Buchanan, McDonald & Evans 1984)	Assessment not required	Assessment not required	Assessment not required	No
Cerosterna scabrator Fabricius 1781 [Coleoptera: Cerambycidae]	Yes (Dixon et al. 2013)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Cerosterna scabrator*. This species is associated with pomegranate stems (Naik, Jagginavar & Biradar 2011).	Assessment not required	Assessment not required	No
Euwallacea similis Ferrari 1867 [Coleoptera: Scolytidae] (synonym: *Xyleborus similis* Ferrari 1867)	Yes (Rabaglia, Dole & Cognato 2006)	Yes (Schedl 1971)	Assessment not required	Assessment not required	Assessment not required	No
Holotrichia insularis Brensk 1894 [Coleoptera: Scarabaeidae] (synonym: *Holotrichia reynaudi* Blanchard 1851)	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Holotrichia insularis*. This species is associated with pomegranate leaves (Butani 1993; USDA 2010).	Assessment not required	Assessment not required	No
Hoplasoma sexmaculata Hope 1831 [Coleoptera: Chrysomelidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Hoplasoma sexmaculata.* This species is associated with pomegranate roots (Balikai, Kotikal & Prasanna 2009).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Mimastra cyanura Hope 1831 [Coleoptera: Chrysomelidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Mimastra cyanura*. This species is associated with pomegranate leaves and roots (Balikai, Kotikal & Prasanna 2009; USDA 2010).	Assessment not required	Assessment not required	No
Myllocerus discolor Boheman 1834 [Coleoptera: Curculionidae]	Yes (Paunikar 2015)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Myllocerus discolor*. This species is associated with pomegranate leaves, shoots and inflorescence (Butani 1993; USDA 2010).	Assessment not required	Assessment not required	No
Myllocerus laetivirens Marshall 1916 [Coleoptera: Curculionidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Myllocerus laetivirens*. This species has been reported to be associated with pomegranate (Balikai, Kotikal & Prasanna 2009; Paunikar 2015). However, pomegranate fruit is not reported to provide a pathway for *Myllocerus laetivirens*. In other hosts, this species is associated with roots and leaves (Talwar 2014).	Assessment not required	Assessment not required	No
Myllocerus maculosus Desbrochers 1823 [Coleoptera: Curculionidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Myllocerus maculosus*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Olenecamptus bilobus Fabricius 1801 [Coleoptera: Cerambycidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Slipinski & Escalona 2016)	Assessment not required	Assessment not required	Assessment not required	No
Tricliona nr *nigra* Jacoby [Coleoptera: Chrysomelidae]	Yes (Jayanthi & Verghese 2014)	Not known to occur	No: Only one report identifies this pest as associated with pomegranate (Jayanthi & Verghese 2014) and acknowledges that there has been no further report of this pest being associated with pomegranate elsewhere in the world. Jayanthi and Verghese (2014) reported that *T. nigra* preferred to feed by surface scraping on all parts of pomegranate, including fruit. Given it is a surface-feeding pest it is likely to be disturbed and removed during harvesting and packing processes.	Assessment not required	Assessment not required	No
Xyleborus fornicatus Eichhoff 1868 [Coleoptera: Scolytidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Geering 2013)	Assessment not required	Assessment not required	Assessment not required	No
Xyleborus perforans Wollastan 1857 [Coleoptera: Scolytidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
DERMAPTERA						
Forficula auricularia Linnaeus 1758 [Dermaptera: Forficulidae]	Yes (Desportes & Schrével 2013)	Yes (Alford 2016)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
DIPTERA						
Bactrocera carambolae Drew & Hancock 1994 [Diptera: Tephritidae] Carambola fruit fly	Yes (CABI 2018; Kapoor 2002). Only reported to occur in the Andaman and Nicobar Islands (Kapoor 2005; PHA 2018)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Bactrocera carambolae*. This species is associated with pomegranate fruit (CABI 2020). Eggs of related species are laid below the rind of the host fruit in which immature stages (larvae) feed (CABI 2020). The introduction of *Bactrocera carambolae* to the United States of America has been linked to the small-scale trade of fruit from Indonesia (Marchioro 2016).	Yes: *Bactrocera carambolae* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Marchioro 2016; van Sauers-Muller 2005). Any areas with hot and humid climates or extremely hot and arid areas are potential establishment sites for this fruit fly (Marchioro 2016). Importation of infested fruit from one area to another is an important means of introduction and spread of fruit flies. In addition, fruit flies are strong flyers (Fletcher 1989) which will contribute to spread in Australia.	Yes: *Bactrocera carambolae* has the potential for economic consequences in Australia. This species is highly polyphagous, feeding on over 100 host plants including avocado, lemon, orange and mango (Marchioro 2016). Estimates indicate that the spread of *Bactrocera carambolae* throughout Brazil may result in economic losses of US$ 30.7 million in the first year (Marchioro 2016). Consequences would include crop losses as well as quarantine restrictions on trade, both within Australia and internationally to areas where this species is not present.	Yes (EP)

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Bactrocera dorsalis Hendel 1912 [Diptera: Tephritidae] (synonym: *Bactrocera invadens* Drew, Tsuruta & White 2005) Oriental fruit fly	Yes (Balikai, Kotikal & Prasanna 2009)	No: Eradicated from mainland Australia (Hancock et al. 2000)	Yes: Pomegranate fruit provides a pathway for *Bactrocera dorsalis*. This species is associated with pomegranate fruit (Jose, Cugala & Santos 2013). Adults lay batches of 1–20 eggs in a single fruit in which immature stages (larvae) feed (FDACS 2017).	Yes: *Bactrocera dorsalis* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (De Villiers et al. 2015). Importation of infested fruit from one area to another is an important means of introduction and spread of fruit flies. Fruit flies are strong flyers (Fletcher 1989); therefore, adult flight and the transport of infected fruit could assist the spread of *Bactrocera dorsalis* in Australia. After introduction, it can easily spread as it has high reproductive potential and high biotic potential (short life cycle, up to 10 generations of offspring per year depending on temperature), a rapid dispersal ability (can fly 50km to 100km) and a broad host range (Duyck, Sterlin & Quilici 2004; IPPC 2017b; Sridhar et al. 2014).	Yes: *Bactrocera dorsalis* has the potential for economic consequences in Australia. This species is highly polyphagous, feeding on over 150 host plants (Allwood et al. 1999). Without control, direct damage of up to 100% has been reported on mango in Africa (Nankinga et al. 2014). Guava crops in India have reported crop losses of up to 70% (Verghese et al. 2002). Consequences would include crop losses as well as quarantine restrictions on trade, both within Australia and internationally to areas where this species is not present.	Yes (EP)

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Bactrocera latifrons Hendel 1915 [Diptera: Tephritidae] Solanum Fruit Fly	Yes (Kapoor 2002)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Bactrocera latifrons*. There is only one record of this pest being associated with pomegranate fruit (Allwood et al. 1999), which is inconclusive as the authors acknowledged that their survey recorded some unusual associations, such as possible opportunistic association and inconclusive host status. No further record could be found to support this pest's association with pomegranate fruit.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Bactrocera zonata Saunders 1842 [Diptera: Tephritidae] (synonym: *Dacus zonatus* Saunders 1842) Peach fruit fly	Yes (Allwood et al. 1999; Balikai, Kotikal & Prasanna 2009)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Bactrocera zonata*. This species is associated with pomegranate fruit (Alzubaidy 2000). Eggs of related species are laid below the rind of the host fruit in which immature stages (larvae) feed (CDFA 2018). This fruit fly can also be transported in fruit packaging material (EPPO 2015a).	Yes: *Bactrocera zonata* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Alzubaidy 2000). *Bactrocera zonata* is mainly a tropical species and areas with an upper temperature limit of 35°C are potential establishment sites (Duyck, Sterlin & Quilici 2004). Importation of infested fruit from one area to another is an important means of introduction and spread of fruit flies. *Bactrocera zonata* is a strong flyer (Qureshi et al. 1974) and readily disperses as far as 40km, even when hosts are abundant (Fletcher 1989; Qureshi et al. 1974).	Yes: *Bactrocera zonata* has the potential for economic consequences in Australia. This species is highly polyphagous, feeding on over 50 host plants material (Alzubaidy 2000; EPPO 2015a). The estimated annual cost of *Bactrocera zonata* in Egypt is over US$ 177 million (Alzubaidy 2000). Extensive crop losses have been reported in Asia (25% to 100%) and the Middle East (30% to 50%) (Alzubaidy 2000; Mahmoud et al. 2017). Consequences would include crop losses as well as quarantine restrictions on trade, both within Australia and internationally to areas where this species is not present.	Yes (EP)
HEMIPTERA						
Acaudaleyrodes rachipora Singh 1931 [Hemiptera: Aleyrodidae]	Yes (Dubey & Ko 2008)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Acaudaleyrodes rachipora*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Aleurocanthus spiniferus Quaintance 1903 [Hemiptera: Aleyrodidae]	Yes (Dubey & Sundararaj 2004)	Yes (Naumann 1993). Listed as a Declared Organism (Prohibited (section 12)) for WA (Government of Western Australia 2018)	No: Pomegranate fruit does not provide a pathway for *Aleurocanthus spiniferus*. This species is associated with pomegranate leaves and twigs (Cocuzza et al. 2016).	Assessment not required	Assessment not required	No
Aleurocanthus woglumi Ashby 1915 [Hemiptera: Aleyrodidae]	Yes (Dubey & Sundararaj 2004; Evans 2007)	Not known to occur on mainland Australia (Recorded on Christmas and Cocos Islands (Bellis et al. 2004)	No: Pomegranate fruit does not provide a pathway for *Aleurocanthus woglumi*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Aleurodicus dispersus Russell 1965 [Hemiptera: Aleyrodidae]	Yes (Boopathi et al. 2014)	Yes (Botha, Hardie & Power 2000; Naumann 1993). Listed as a Declared Organism (Prohibited (section 12)) for WA (Government of Western Australia Department of Primary Industries and Regional Development 2018) and listed as declared exotic for Victoria (Agriculture Victoria 2017)	No: Pomegranate fruit does not provide a pathway for *Aleurodicus dispersus*. This species is associated with pomegranate leaves (Ananda 2007; USDA 2010).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Andaspis hawaiiensis Maskell 1896 [Hemiptera: Diaspididae] (synonym: *Lepidosaphes hawaiiensis* Merrill 1953)	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Andaspis hawaiiensis*. This species is associated with pomegranate inflorescence (Murugesan, Kumar & Sundararaj 1996).	Assessment not required	Assessment not required	No
Aonidiella aurantii Maskell 1879 [Hemiptera: Diaspididae]	Yes (Willson & Clifford 2012)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Aonidiella orientalis Newstead 1894 [Hemiptera: Diaspididae] (synonym: *Aspidiotus orientalis* Newstead 1894)	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Aphis craccivora Koch 1854 [Hemiptera: Aphididae]	Yes (Singh & Singh 2017)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Aphis fabae Scopoli 1763 [Hemiptera: Aphididae]	Yes (CABI 2020)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Aphis fabae*. This species has been reported to be associated with pomegranate leaves (Ghosh & Singh 2004; USDA 2010).	Assessment not required	Assessment not required	No
Aphis gossypii Glover 1877 [Hemiptera: Aphididae]	Yes (Agarwala & Choudhuri 2014)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Aphis punicae Passerini 1863 [Hemiptera: Aphididae] Pomegranate aphid	Yes (Balikai, Kotikal & Prasanna 2009; Sreedevi & Verghese 2007b)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Aphis punicae*. This species is associated with pomegranate fruit, tender shoots, flower buds and flowers (Ananda 2007; Cocuzza et al. 2016; Sreedevi et al. 2006).	Yes: *Aphis punicae* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Blackman & Eastop 2008). This species is polyphagous, feeding on several host plants (Cocuzza et al. 2016). Some of these hosts are widespread in Australia. Female alates of this species may be able to access hosts in the environment via wind dispersal.	Yes: *Aphis punicae* has the potential for economic consequences in Australia. This species is of economic importance for pomegranates; considerable yield loss occurs due to direct damage to fruit and by production of honeydew on which sooty mould develops (Sreedevi et al. 2006).	Yes
Aspidiotus nerii Bouche 1833 [Hemiptera: Diaspididae]	Yes (USDA 2010)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Bemisia tabaci Gennadius 1889 [Hemiptera: Aleyrodidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Naumann 1993). However, it is a known vector of a number of plant viruses including quarantine pests for Australia, for example, Tomato yellow leaf curl virus (TYLCV) and Tomato yellow leaf curl China virus (TYLCCV) (Li et al. 2014; Pan et al. 2012)	No: This species is a phloem feeder and females lay eggs on the underside of leaves. Adults superficially feed on fruits (CABI 2018; Guo et al. 2018; Li et al. 2011). Adult whiteflies are very active and are unlikely to remain on the fruit when disturbed during harvesting and packing processes. However, if detected at the border, risk assessment will be required, consistent with Section 5.3 of this report.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Brachycaudus helichrysi Kaltenbach 1843 [Hemiptera: Aphididae]	Yes (Rebijith et al. 2013)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Ceroplastes floridensis Comstock 1881 [Hemiptera: Coccidae]	Yes (Mani 2016)	Yes (Naumann 1993). Listed as a Declared Organism (Prohibited (section 12)) for WA (Government of Western Australia 2018).	No: Pomegranate fruit does not provide a pathway for *Ceroplastes floridensis*. This species is associated with pomegranate leaves, branches and twigs (Cocuzza et al. 2016).	Assessment not required	Assessment not required	No
Ceroplastes rusci Linnaeus 1758 [Hemiptera: Coccidae]	Yes (Mani 2016)	Yes (Waterhouse & Sands 2001)	Assessment not required	Assessment not required	Assessment not required	No
Ceroplastes rubens Maskell 1893 [Hemiptera: Coccidae]	Yes (Gimpel, Miller & Davidson 1974)	Yes (Waterhouse & Sands 2001)	Assessment not required	Assessment not required	Assessment not required	No
Chrysomphalus rossi Maskell 1892 [Hemiptera: Diaspididae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Coccus hesperidum Linnaeus 1758 [Hemiptera: Coccidae]	Yes (Mani 2016)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Dolycoris indicus Stål 1876 [Hemiptera: Pentatomidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Dolycoris indicus*. This species has been reported to be associated with pomegranate (Balikai, Kotikal & Prasanna 2009). However, pomegranate fruit is not reported to provide a pathway for *Dolycoris indicus*. In other hosts, this species is associated with leaves and inflorescence (Peter 2009; Thirumurthi, Udayasoorian & Balamurugan 1989).	Assessment not required	Assessment not required	No
Drosicha dalbergiae (Stebbing 1902) [Hemiptera: Monophlebidae] Almond mealy bug	Yes (Rawat, Pawar & Chand 1989; Varshney, Jadhav & Sharma 2015)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Drosicha dalbergiae.* This species is associated with pomegranate fruit (Rawat, Pawar & Chand 1989; USDA 2010).	Yes: *Drosicha dalbergiae* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in India and Taiwan (García Morales et al. 2018). This species is polyphagous, feeding on eight genera in seven families (Ali 1968). Some of these hosts are widespread in Australia.	Yes: *Drosicha dalbergiae* has the potential for economic consequences in Australia. This species has been recorded reducing quality and yield of almond crops (Koul et al. 2000) and attacking up to 25% of fruit on wild pomegranate plants (Rawat, Pawar & Chand 1989). In addition, this species excretes honeydew that can cover the fruit and promote sooty mould growth making fruit unmarketable (Mani & Shivaraju 2016).	Yes
Drosicha mangiferae Green 1903 [Hemiptera: Monophlebidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Drosicha mangiferae*. This species is associated with pomegranate leaves (Hill 1987).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Duplaspidiotus tesseratus Grandpré & Charmoy 1899 [Hemiptera: Diaspididae] (synonym: *Aspidiotus tesseratus* Grandpré & Charmoy)	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Duplaspidiotus tesseratus*. This species has been reported to be associated with pomegranate (Balikai, Kotikal & Prasanna 2009; USDA 2010). However, pomegranate fruit is not reported to provide a pathway for *Duplaspidiotus tesseratus*. In other hosts, this species is associated with bark (Miller & Davidson 2005).	Assessment not required	Assessment not required	No
Dysmicoccus neobrevipes Beardsley 1959 [Hemiptera: Pseudococcidae] Grey pineapple mealybug; Annona mealybug	Yes (Mani, Smitha & Najitha 2016)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Dysmicoccus neobrevipes*. This species is associated with pomegranate fruit (USDA 2010).	Yes: *Dysmicoccus neobrevipes* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species is highly polyphagous, feeding on over 30 plant families (Ben-Dov 1994). Some of the hosts are widespread in Australia. This species has established in areas with a wide range of climatic conditions (Williams 2004). Mealybugs may be able to access hosts in the environment via wind dispersal (da Silva-Torres, de Oliveira & Torres 2013).	Yes: *Dysmicoccus neobrevipes* has the potential for economic consequences in Australia. This species is an important pest of pineapple (Williams 2004). *Dysmicoccus neobrevipes* causes direct damage through feeding and, by producing honeydew on which sooty mould develops, can render fruit unmarketable (Qin et al. 2011).	Yes (EP): Mealybugs Group PRA will be applied when finalised.

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Helopeltis antonii Signoret 1858 [Hemiptera: Miridae]	Yes (Jayanthi et al. 2016)	Not known to occur	No: Mature pomegranate fruit does not provide a pathway for *Helopeltis antonii*. This species feeds on pomegranate shoots, young leaves, inflorescence and immature fruit (Jayanthi et al. 2016). Consequently, it is not expected to be on the pathway of mature fruit at the time of harvest.	Assessment not required	Assessment not required	No
Hemaspidoproctus cinereus Green 1922 [Hemiptera: Coccidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Hemaspidoproctus cinereus.* This species is associated with pomegranate leaves (Bohra, Doval & Sharma 1970; USDA 2010).	Assessment not required	Assessment not required	No
Hemiberlesia punicae Signoret 1869 [Hemiptera: Diaspididae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Hemiberlesia punicae*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Hemiberlesia rapax Comstock 1881 [Hemiptera: Diaspididae]	Yes (Butani 1993)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Hemichionaspis theae Cooley 1899 [Hemiptera: Diaspididae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Hemichionaspis theae*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Howardia biclavis Comstock 1883 [Hemiptera: Diaspididae]	Yes (Miller & Davidson 2005)	Yes (Muthaiyan 2009; Naumann 1993). Listed as a Declared Organism (Prohibited (section 12)) for WA (Government of Western Australia 2018).	No: Pomegranate fruit does not provide a pathway for *Howardia biclavis*. This species has been reported to be associated with pomegranate (Kuwana 1909). However, pomegranate fruit is not reported to provide a pathway for *Howardia biclavis*. In other hosts, this species is associated with sap and bark (Hamasaki, Shimabuku & Nakamoto 2008).	Assessment not required	Assessment not required	No
Icerya aegyptiaca Douglas 1890 [Hemiptera: Margarodidae]	Yes (Meena et al. 2012)	Yes (Hill 1987; Muniappan et al. 2012)	Assessment not required	Assessment not required	Assessment not required	No
Icerya purchasi Maskell 1878 [Hemiptera: Margarodidae]	Yes (Balikai, Kotikal & Prasanna 2009; CABI 2018)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Icerya seychellarum Westwood 1855 [Hemiptera: Margarodidae]	Yes (Guerrero et al. 2012)	Yes (Guerrero et al. 2012; Poole 2008; Sands & van Driesche 2004)	Assessment not required	Assessment not required	Assessment not required	No
Jurtina indica Dallas 1851 [Hemiptera: Pentatomidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No. *Jurtina indica* is infrequently associated with pomegranate (Raghunatha 1999). It is a pentatomid stink bug that feeds externally on the fruit and is likely to be removed during harvest and packing house processes.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Kerria lacca Kerr 1782 [Hemiptera: Kerridae]	Yes (Raman 2014)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Kerria lacca*. This species is associated with pomegranate stems (USDA 2010).	Assessment not required	Assessment not required	No
Lepidosaphes punicae Green 1929 [Hemiptera: Diaspididae] (synonym: *Andaspis punicae* Laing 1929)	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Lepidosaphes punicae*. This species is associated with pomegranate bark (García Morales et al. 2018).	Assessment not required	Assessment not required	No
Leptoglossus australis Fabricius 1775 [Hemiptera: Coreidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Naumann 1993; Schaefer & Panazzi 2000)	Assessment not required	Assessment not required	Assessment not required	No
Lindingaspis greeni Brain & Kelly 1917 [Hemiptera: Disapidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Lindingaspis greeni*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Lopholeucaspis japonica Cockerell 1897 [Hemiptera: Diaspididae] (synonym: *Leucaspis japonica darwiniensis* Green 1916)	Yes (Harsur, Joshi & Pal 2018)	No: Identified in Northern Territory but not established (Green 1916; Smith et al. 1997)	No: Pomegranate fruit does not provide a pathway for *Lopholeucaspis japonica*. This species is associated with pomegranate stems, branches and twigs (Harsur, Joshi & Pal 2018; ICAR 2017).	Assessment not required	Assessment not required	No
Myzus ornatus Laing 1932 [Hemiptera: Aphididae]	Yes (USDA 2010)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Nezara viridula Linnaeus 1758 [Hemiptera: Pentatomidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Paracoccus marginatus Williams & Granara de Willink 1992 [Hemiptera: Pseudococcidae] Papaya mealybug	Yes (Muniappan et al. 2008)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Paracoccus marginatus*. This species is associated with pomegranate fruit (Sakthivel et al. 2012).	Yes: *Paracoccus marginatus* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species is highly polyphagous, feeding on over 130 species from 48 families (Sakthivel et al. 2012). Some of the hosts are widespread in Australia. This species has established in areas with a wide range of climatic conditions (Amarasekare et al. 2008; Pantoja, Follett & Villanueva-Jimenez 2002). Mealybugs may be able to access hosts in the environment via wind dispersal (da Silva-Torres, de Oliveira & Torres 2013).	Yes: *Paracoccus marginatus* has the potential for economic consequences in Australia. This species causes damage to a wide variety of economically important crops, including avocado, citrus, cotton and mango (Saengyot & Burikam 2011). This species has been reported to infest up to 100% of papaya plants on farms in Sri Lanka (Galanihe et al. 2010). Infestation by *Paracoccus marginatus* on host plants can lead to a build-up of thick white wax on fruit and/or early fruit drop (Sharma et al. 2013).	Yes (EP): Mealybugs Group PRA will be applied.
Parasaissetia nigra Neitner 1861 [Hemiptera: Coccidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Lin et al. 2017; Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Parlatoria oleae Colvee 1880 [Hemiptera: Coccidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (García Morales et al. 2018; Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Parthenolecanium persicae Fabricius 1776 [Hemiptera: Coccidae]	Yes (Varshney, Jadhav & Sharma 2012)	Yes (Naumann 1993; Rakimov et al. 2013)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Planococcus ficus Signoret 1875 [Hemiptera: Pseudococcidae] Vine mealybug	Yes (Ben-Dov 1994; Suroshe et al. 2016; Walton 2003)	Not known to occur	Yes: Pomegranate fruit may provide a pathway for *Planococcus ficus*. This species is associated with pomegranate fruit and leaves (Miller et al. 2014; Suroshe et al. 2016).	Yes: *Planococcus ficus* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (García Morales et al. 2018). This species is highly polyphagous, feeding on over 28 genera in 23 plant families (Daane & Bentley 2003; García Morales et al. 2018). Some of these hosts are widespread in Australia. Mealybugs may be able to access hosts in the environment via wind dispersal (da Silva-Torres, de Oliveira & Torres 2013).	Yes: *Planococcus ficus* has the potential for economic consequences in Australia. This polyphagous species is considered an economically important pest of grapevines in Argentina, the Mediterranean region, Pakistan, South Africa and the United States of America (Millar et al. 2002; Walton et al. 2006; Walton, Daane & Pringle 2004). This species causes progressive weakening of vines through early leaf loss, yield loss and reduced crop quality (Walton et al. 2006; Walton, Daane & Pringle 2004).	Yes (EP): Mealybugs Group PRA will be applied when finalised.
Pulvinaria psidii Maskell 1893 [Hemiptera: Coccidae]	Yes (García Morales et al. 2018; Mani 2016)	Yes (García Morales et al. 2018; Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Saissetia coffeae Walker 1852 [Hemiptera: Coccidae]	Yes (Reddy & Sharma 2015)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Saissetia oleae Olivier 1791 [Hemiptera: Coccidae]	Yes (García Morales et al. 2018)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Siphoninus phillyreae Haliday 1835 [Hemiptera: Aleyrodidae] (synonym: *Siphonimus finitimus* Silvestri 1915)	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Evans 2007; Martin 1999)	Assessment not required	Assessment not required	Assessment not required	No
Toxoptera aurantii Boyer de Fonscolombe 1841 [Hemiptera: Aphididae]	Yes (Agarwala & Bhattacharya 1995; Ghosh et al. 2015)	Yes (Carver & Franzmann 2001)	Assessment not required	Assessment not required	Assessment not required	No
Trialeurodes vaporariorum Westwood 1856 [Hemiptera: Aleyrodidae]	Yes (CABI 2020)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
ISOPTERA						
Odontotermes obesus Rambur 1913 [Isoptera: Termitidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Odontotermes obesus*. This species is associated with pomegranate roots and trunk (Reddy & Sreedevi 2016).	Assessment not required	Assessment not required	No
Trinervitermes biformis Wasmann 1902 [Isoptera: Termitidae]	Yes (Kaur et al. 2017)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Trinervitermes biformis*. This species is associated with pomegranate roots (USDA 2010).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
LEPIDOPTERA						
Acanthopsyche cana Hampson 1892 [Lepidoptera: Psychidae]	Yes (Dhileepan 1991)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Acanthopsyche cana*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Achaea janata Linnaeus 1758 [Lepidoptera: Noctuidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Edwards 1978; Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Actias selene Hübner 1806 [Lepidoptera: Saturniidae]	Yes (Hill 2012)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Actias selene*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Anatrachyntis simplex Walsingham 1891 [Lepidoptera: Cosmopterigidae] (synonym: *Pyroderces simplex* Walsingham 1891) Flower eating caterpillar; False pink bollworm	Yes (Balikai, Kotikal & Prasanna 2009; David & Ananthakrishnan 2004)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Anatrachyntis simplex*. This species is associated with rotten pomegranate fruit (Heckford 2004; Mathur, Singh & Lal 1958). A comprehensive literature search indicates that there is no strong evidence to associate *Anatrachyntis simplex* with commercial-grade pomegranate fruit. A larva was reported to be found on the calyx of an imported pomegranate fruit in a retail store in the UK (Heckford 2004); however, it is unknown whether the species was imported with the fruit. On other hosts, *Anatrachyntis simplex* is described as a scavenger feeder, rather than a primary pest (Chamberlain 1993; Fletcher 1920).	Assessment not required	Assessment not required	No
Apomyelois ceratoniae Zeller 1839 [Lepidoptera: Pyralidae]	Yes (Azqandi, Kazazi & Abdul Ahadi 2015)	Yes (Azqandi, Kazazi & Abdul Ahadi 2015; Madge, Taylor & Williams 2016)	Assessment not required	Assessment not required	Assessment not required	No
Archips micaceana Walker 1863 [Lepidoptera: Tortricidae]	Yes (Waller, Bigger & Hillocks 2007)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Archips micaceana*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Arcyophora dentula Lederer 1870 [Lepidoptera: Noctuidae]	Yes (Balikai, Kotikal & Prasanna 2009; Mukerjee 1941)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Arcyophora dentula.* This species is associated with pomegranate leaves (Balikai, Kotikal & Prasanna 2009; Mukerjee 1941).	Assessment not required	Assessment not required	No
Cadra cautella Walker 1863 [Lepidoptera: Pyralidae] (synonym: *Ephestia cautella* Walker 1863)	Yes (Thangjam, Damayanti & Sharma 2003)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Clania crameri (Westwood 1854) [Lepidoptera: Psychidae] (synonym: *Eumeta crameri* Westwood 1854)	Yes (Balikai, Kotikal & Prasanna 2009; Hill 1983)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Clania crameri.* This species is associated with pomegranate leaves, tender shoots and bark (Abrol 2015; Hill 1983; Mani, Shivaraju & Kulkarni 2014).	Assessment not required	Assessment not required	No
Conogethes punctiferalis Guenée 1854 [Lepidoptera: Pyralidae] (synonym: *Dichocrocis punctiferalis* Guenee)	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Creatonotus gangis (Linnaeus 1763) [Lepidoptera: Arctiidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Nielsen, Edwards & Rangsi 1996; Zborowski & Edwards 2007)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cryptoblabes gnidiella Millière 1867 [Lepidoptera: Pyralidae] Honeydew moth	Yes (Molet 2013; Sellanes, Rossini & González 2010)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Cryptoblabes gnidiella*. This species is associated with pomegranate fruit (Avidov & Harpaz 1969b; Carter 1984). *Cryptoblabes gnidiella* larvae feed in the pomegranate fruit (Guario 2018). This species has been intercepted on pomegranate fruit imported into Poland and the United Kingdom (Dawidowicz & Rozwalka 2016).	Yes: *Cryptoblabes gnidiella* has the potential to establish and spread in Australia as suitable hosts and environments are available. This polyphagous moth of Mediterranean origin has been introduced and established in many regions with a similar climate, particularly in cultivable areas (Dawidowicz & Rozwalka 2016). The flying adults of this species are able to disperse independently to find suitable hosts (Dawidowicz & Rozwalka 2016).	Yes: *Cryptoblabes gnidiella* has the potential for economic consequences in Australia. This species is an economically important pest of several economically important horticulture crops including avocado, citrus, grapes, loquat and pomegranate (Ascher et al. 1983; Cocuzza et al. 2016). This species is a quarantine pest for the USA (USDA 2010). The introduction of this pest into Australia could restrict access to overseas markets.	Yes (EP)
Deudorix epijarbas Moore 1858 [Lepidoptera: Lycaenidae] Lycaenid fruit borer; Cornelian butterfly	Yes (Kumar 2014)	Yes (Braby & Douglas 2004; Nielsen, Edwards & Rangsi 1996). Listed as a Declared Organism (Prohibited (section 12)) for WA (Government of Western Australia 2018)	Yes: Pomegranate fruit provides a pathway for *Deudorix epijarbas*. This species is associated with pomegranate fruit (Hill 1987). *Deudorix epijarbas* larvae bore into the fruit and feed upon the pulp and seeds (Thakur et al. 1995). *Deudorix epijarbas* attacks pomegranate fruit from early stages through to maturity (Mohi-Ud-Din et al. 2015).	Yes: *Deudorix epijarbas* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in Queensland, Indonesia, Papua New Guinea, Solomon Islands and Oriental Region (Edwards, Newland & Regan 2001). This species is polyphagous, feeding on several host plants (Braby 1997; Hill 2008; Loc, Kumar & Chakravarthy 2018; Waite & Hwang 2002; Zaka-Ur-Rab 1980). Some of these hosts are widespread in Australia. The flying adults of this species are able to disperse independently to find suitable hosts.	Yes: *Deudorix epijarbas* has the potential for economic consequences in Australia. *Deudorix epijarbas* caterpillars can significantly reduce yields in pomegranate (Chauhan & Kanwar 2012). In India, reports have been made of *Deudorix epijarbas* infestations of up to 60% in pomegranate (Gupta & Dubey 2005).	Yes (WA)

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Deudorix isocrates Fabricius 1793 [Lepidoptera: Lycaenidae] (synonym: *Virachola isocrates* Fabricius) Common guava blue; Pomegranate butterfly	Yes (Bagle 2011; Balikai, Kotikal & Prasanna 2009)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Deudorix isocrates*. This species is associated with pomegranate fruit, stalks and leaves (Chhetry, Gupta & Tara 2015; Kumar 2014). *Deudorix isocrates* bore into fruit and feed upon the pulp and seeds (Chhetry, Gupta & Tara 2015; Kumar 2014; Kumar et al. 2017).	Yes: *Deudorix isocrates* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Kumar 2014). The flying adults of this species are able to disperse independently to find suitable hosts.	Yes: *Deudorix isocrates* has the potential for economic consequences in Australia. In India, reports have been made of *Deudorix isocrates* infestations of up to 90% in pomegranate (Bagle 2011) and up to 26.4% in Guava (Rama Devi & Jha 2017), as well as up to 18% damage to oranges (Chhetry, Gupta & Tara 2015).	Yes
Dysgonia algira Linnaeus 1767 [Lepidoptera: Noctuidae]	Yes (Rose 2002)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Dysgonia algira*. This species is associated with pomegranate leaves (Cocuzza et al. 2016).	Assessment not required	Assessment not required	No
Ercheia diversipennis Walker 1857 [Lepidoptera: Noctuidae]	Yes (Shubhalaxmi et al. 2011)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Ercheia diversipennis*. This species feeds on damaged pomegranate fruit (Bhumannavar & Viraktamath 2001; USDA 2010). Consequently, it is not expected to be on the pathway of mature fruit at the time of harvest.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Eudocima cajeta Cramer 1775 [Lepidoptera: Noctuidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Eudocima cajeta*. This species feeds externally on pomegranate fruit (Balikai, Kotikal & Prasanna 2009; Peter 2009). Consequently, it is not expected to be on the pathway of mature fruit at the time of harvest.	Assessment not required	Assessment not required	No
Eudocima fullonia Clerck 1764 [Lepidoptera: Noctuidae] (synonym: *Othreis fullonica* Linnaeus)	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Fay & Halfpapp 1999; Nielsen, Edwards & Rangsi 1996)	Assessment not required	Assessment not required	Assessment not required	No
Eudocima homaena Hübner 1816 [Lepidoptera: Noctuidae] (synonym*: Othreis homaena* Hübner 1823)	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Eudocima homaena*. Adults of this species are nocturnal fruit-piercing moths which suck juice from pomegranate fruit (Jayanthi et al. 2015). Consequently, it is not expected to be on the pathway of mature fruit at the time of harvest.	Assessment not required	Assessment not required	No
Eudocima materna Linnaeus 1767 [Lepidoptera: Noctuidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Yes (Fay & Halfpapp 1999; Nielsen, Edwards & Rangsi 1996)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Euproctis flava Bremer 1861 [Lepidoptera: Lymantriidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Euproctis flava*. This species is associated with pomegranate leaves (Jha & Sen-Sarma 2012).	Assessment not required	Assessment not required	No
Euproctis fraterna Moore 1883 [Lepidoptera: Lymantriidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Mature pomegranate fruit does not provide a pathway for *Euproctis fraterna*. This species feeds on pomegranate tender leaves, buds, flowers and immature fruit (David & Ananthakrishnan 2004; Jha & Sen-Sarma 2012; Suroshe et al. 2016). Consequently, it is not expected to be on the pathway of mature fruit at the time of harvest.	Assessment not required	Assessment not required	No
Euproctis lunata Walker 1855 [Lepidoptera: Lymantriidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Euproctis lunata.* This species is associated with pomegranate leaves (Jha & Sen-Sarma 2012; Khan et al. 2014).	Assessment not required	Assessment not required	No
Euproctis scintillans Walker 1856 [Lepidoptera: Lymantriidae] (synonyms: *Somena scintillans* Walker 1856; *Porthesia scintillans* Walker 1856)	Yes (Balikai, Kotikal & Prasanna 2009; Suroshe et al. 2016)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Euproctis scintillans*. This species is associated with pomegranate leaves, tender shoots, buds and branch tips (Jha & Sen-Sarma 2012; Suroshe et al. 2016).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Helicoverpa armigera Hübner 1809 [Lepidoptera: Noctuidae]	Yes (Romeis & Shanower 1996)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Indarbela dea Swinhoe 1890 [Lepidoptera: Arbelidae]	Yes (Reddy & Sreedevi 2016)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Indarbela dea*. This species is associated with pomegranate stems and bark (USDA 2010).	Assessment not required	Assessment not required	No
Indarbela quadrinotata (Walker 1856) [Lepidoptera: Arbelidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Indarbela quadrinotata.* This species is associated with pomegranate bark (Balikai, Kotikal & Prasanna 2009).	Assessment not required	Assessment not required	No
Indarbela tetraonis Moore 1879 [Lepidoptera: Arbelidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Indarbela tetraonis*. This species is associated with pomegranate bark (Balikai, Kotikal & Prasanna 2009).	Assessment not required	Assessment not required	No
Iraota timoleon Stoll 1790 [Lepidoptera: Lycaenidae]	Yes (Kasambe 2016)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Iraota timoleon*. This species is associated with pomegranate stems, leaves and inflorescence (Kasambe 2016; USDA 2010).	Assessment not required	Assessment not required	No
Latoia lepida Cramer 1799 [Lepidoptera: Limacodidae] (synonym: *Parasa lepida* Cramer 1779)	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Latoia lepida*. This species is associated with pomegranate leaves (Hill 1987, 2008).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Leucinodes orbonalis Guenée 1854 [Lepidoptera: Crambidae]	Yes (Chakraborti & Sarkar 2011)	Yes (Nielsen, Edwards & Rangsi 1996). Listed as a Declared Organism (Prohibited (section 12)) for WA (Government of Western Australia 2018)	No: Pomegranate fruit does not provide a pathway for *Leucinodes orbonalis*. This species has been reported to be associated with pomegranate (Korycinska & Cannon 2010). However, based on published literature, pomegranate fruit is not reported to provide a pathway for *Leucinodes orbonalis*.	Assessment not required	Assessment not required	No
Lymantria ampla Walker 1855 [Lepidoptera: Lymantriidae]	Yes (Bharamal 2015)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Lymantria ampla*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Lymantria beatrix Stoll 1790 [Lepidoptera: Lymantriidae]	Yes (Kamata et al. 2001)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Lymantria beatrix*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Olene mendosa Hübner 1823 [Lepidoptera: Lymantriidae] (synonym: *Dasychira mendosa*)	Yes (Suroshe et al. 2016)	Yes (Hill 2008; Nielsen, Edwards & Rangsi 1996). Listed as a Declared Organism (Prohibited (section 12)) for WA (Government of Western Australia 2018).	No: Mature pomegranate fruit does not provide a pathway for *Olene mendosa*. This species feeds on tender shoots, buds, flowers and immature fruit (Suroshe et al. 2016). Consequently, it is not expected to be on the pathway of mature fruit at the time of harvest.	Assessment not required	Assessment not required	No

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Ophiusa tirhaca Cramer 1777 [Lepidoptera: Noctuidae]	Yes (Bhumannavar & Viraktamath 2001)	Yes (Nielsen, Edwards & Rangsi 1996)	Assessment not required	Assessment not required	Assessment not required	No
Paralipsa gularis Zeller 1877 [Lepidoptera: Pyralidae] (synonym: *Aphomia gularis* Zeller 1877)	Yes (Hagstrum & Subramanyam 2016)	Yes (Bowditch & Madden 1997; Herbison-Evans & Crossley 2015; Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Phthorimaea operculella Zeller 1873 [Lepidoptera: Gelechiidae]	Yes (Chandel et al. 2013)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Plodia interpunctella Hübner 1813 [Lepidoptera: Pyralidae]	Yes (Kumar 2017)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Pyralis farinalis Linnaeus 1758 [Lepidoptera: Pyralidae]	Yes (Nimbalkar & Shinde 2015)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No
Spodoptera litura Fabricius 1775 [Lepidoptera: Noctuidae]	Yes (Mallikarjuna et al. 2004)	Yes (Naumann 1993)	Assessment not required	Assessment not required	Assessment not required	No

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Stathmopoda auriferella Walker 1864 [Lepidoptera: Oecophoridae] Apple helidionid	Yes (van der Gaag & van der Straten 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Stathmopoda auriferella*. A comprehensive literature search indicates that there is no strong evidence to associate *Stathmopoda auriferella* with commercial-grade pomegranate fruit. Two larvae were reported to be found on the calyx of an imported pomegranate fruit in a retail store in the UK (Heckford 2013); however, it is unknown whether the species was imported with the fruit. On other hosts, *Stathmopoda auriferella* is described as a scavenger feeder, rather than a primary pest (Koster & Sinev 2003).	Assessment not required	Assessment not required	No
Streblote siva Lefèbvre 1827 [Lepidoptera: Lasiocampidae]	Yes (Sharma 2016)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Streblote siva.* This species is associated with pomegranate leaves (USDA 2010; Zolotuhin & Zahiri 2008).	Assessment not required	Assessment not required	No
Suana concolor Walker 1855 [Lepidoptera: Lasiocampidae]	Yes (Senior-White 1920)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Suana concolor*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Thosea sinensis Walker 1855 [Lepidoptera: Limacodidae]	Yes (Gupta, Sharma & Rani 2016)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Thosea sinensis*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Thosea unifascia Walker 1855 [Lepidoptera: Limacodidae]	Yes (Cotes & Swinhoe 1887)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Thosea unifascia*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Trabala vishnou Lefebvre 1827 [Lepidoptera: Lasiocampidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Trabala vishnou*. This species is associated with pomegranate leaves (Kumar et al. 2013a; USDA 2010).	Assessment not required	Assessment not required	No
Zeuzera coffeae Nietner 1861 [Lepidoptera: Cossidae]	Yes (Balikai, Kotikal & Prasanna 2009)	Not known to occur	No: Pomegranate fruit does not provides a pathway for *Zeuzera coffeae.* This species is associated with pomegranate stems (Hill 1987; USDA 2010).	Assessment not required	Assessment not required	No

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THYSANOPTERA						
Frankliniella occidentalis Pergande 1895 [Thysanoptera: Thripidae] Western flower thrips	Yes (CABI 2018; Tyagi & Kumar 2015)	Yes (Kirk & Terry 2003; Malipatil et al. 1993). Declared and Notifiable Pest in NT (DPIR 2018).	Yes: Pomegranate fruit provides a pathway for *Frankliniella occidentalis*. This species is associated with pomegranate flowers (Liu et al. 2014; Wohlfarter, Giliomee & Venter 2010) and has been intercepted on pomegranate fruit imported into Australia from the USA.	Yes: As assessed in the thrips Group PRA (Australian Government Department of Agriculture and Water Resources 2017).	Yes: As assessed in the thrips Group PRA (Australian Government Department of Agriculture and Water Resources 2017).	Yes (NT) (EP): Thrips Group PRA applied (Australian Government Department of Agriculture and Water Resources 2017).
Scirtothrips dorsalis Hood 1919 [Thysanoptera: Thripidae] Chilli thrips	Yes (Balikai, Kotikal & Prasanna 2009; Tyagi & Kumar 2014)	Yes (Mound, Tree & Paris 2018) However, assessed as vector of emerging quarantine tospoviruses (Australian Government Department of Agriculture and Water Resources 2017).	Yes: Pomegranate fruit provides a pathway for *Scirtothrips dorsalis*. This species is associated with pomegranate fruit (Kumar & Vishwakarma 2018).	Yes: Not applicable to vector. However, the emerging quarantine tospoviruses vectored by this thrips have potential for establishment and spread (Australian Government Department of Agriculture and Water Resources 2017).	Yes: Not applicable to vector. However, the emerging quarantine tospoviruses vectored by this thrips have potential for consequences (Australian Government Department of Agriculture and Water Resources 2017).	Yes: Thrips Group PRA applied (Australian Government Department of Agriculture and Water Resources 2017).

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Scirtothrips oligochaetus Karny 1926 [Thysanoptera: Thripidae] (synonym: *Anaphothrips oligochaetus* Kerny 1926) Mangosteen thrips	Yes (Balikai, Kotikal & Prasanna 2009; Chakraborty et al. 2019)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Scirtothrips oligochaetus*. This species is associated with pomegranate leaves, flowers and fruit (Ananda 2007; Balikai, Kotikal & Prasanna 2009).	Yes: As assessed in the thrips group PRA (Australian Government Department of Agriculture and Water Resources 2017).	Yes: As assessed in the thrips group PRA (Australian Government Department of Agriculture and Water Resources 2017).	Yes (EP): Thrips Group PRA applied (Australian Government Department of Agriculture and Water Resources 2017).
BACTERIA						
Agrobacterium rhizogenes (Riker et al. 1930) Conn 1942 [Rhizobiales: Rhizobiaceae] (synonym: *Rhizobium rhizogenes* (Young et al. 2001))	Yes (Murugesan et al. 2010)	Yes (Bradbury 1986; Hoque, Broadhurst & Thrall 2011)	Assessment not required	Assessment not required	Assessment not required	No
Agrobacterium tumefaciens (Smith & Townsend 1907) Conn 1942 [Rhizobiales: Rhizobiaceae] (synonym: *Rhizobium radiobacter* (Beijerinck and van Delden 1902) Young et al. 2001)	Yes (Ansari & Rao 2014)	Yes (Ophel et al. 1988)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Xanthomonas axonopodis pv. *punicae* (Hingorani & Singh 1959) Vauterin et al. 1995 [Xanthomonadales: Xanthomonadaceae] (synonyms: *Xanthomonas punicae* Chand & Kishun 1991; *Xanthomonas campestris* pv. *punicae* (Hingorani & Singh 1959) Dye 1978) Bacterial blight of pomegranate	Yes (Chandra, Jadhav & Sharma 2010; Sharma et al. 2017)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Xanthomonas axonopodis* pv. *punicae.* This species is associated with pomegranate fruit, twigs and leaves (Sharma et al. 2017).	Yes: *Xanthomonas axonopodis* pv. *punicae* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Akhtar & Bhatti 1992; Icoz et al. 2014; Petersen et al. 2010a; Sharma et al. 2017). Spread of this bacterial pathogen from the fruit pathway to a suitable host in Australia will depend on survival, production of inoculum, and availability of a susceptible host.	Yes: *Xanthomonas axonopodis* pv. *punicae* has the potential for economic consequences in Australia. This pathogen is a major constraint in pomegranate production in India (Sharma, Jadhav & Sharma 2011). The blight can cause 50% to 100% production loss depending on disease severity (Siddique & Cook 2010). In unmanaged orchards, losses may extend up to 80% (Sharma, Jadhav & Sharma 2011).	Yes
FUNGI						
Acremonium strictum W. Gams [Hypocreales: Hypocreaceae] (synonym: *Sarocladium strictum* (W. Gams) Summerb.)	Yes (Bandyopadhyay, Mughogho & Satyanarayana 1987)	Yes (Irwin et al. 1999)	Assessment not required	Assessment not required	Assessment not required	No
Alternaria alternata (Fr.) Keissl. [Pleosporales: Pleosporaceae] (synonym: *Alternaria tenuis* Nees)	Yes (Chandra, Jadhav & Sharma 2010)	Yes (Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No

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Alternaria arborescens Simmons [Pleosporales: Pleosporaceae]	Yes (Mercado Vergnes et al. 2006)	Yes (Harteveld, Akinsanmi & Drenth 2014)	Assessment not required	Assessment not required	Assessment not required	No
Alternaria solani (Ellis & G. Martin) L. R. Jones & Grout [Pleosporales: Pleosporaceae]	Yes (Chandra, Jadhav & Sharma 2010; Kumar et al. 2008; Yehia 2013)	Yes (Horsfield et al. 2010; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
Alternaria tenuissima (Kunze) Wiltshire [Pleosporales: Pleosporaceae]	Yes (Raja, Reddy & Allam 2006)	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
Aspergillus awamori Nakaz. [Eurotiales: Aspergillaceae] (Synonym: *Aspergillus niger* var. *awamori* (Nakaz.) Al-Musallam)	Yes (Seth, Alam & Shukla 2016; Thilagam, Nayak & Nanda 2015)	Yes (CSIRO 2019b)	Assessment not required	Assessment not required	Assessment not required	No
Aspergillus flavus Link [Eurotiales: Aspergillaceae]	Yes (Thilagam, Nayak & Nanda 2015)	Yes (Hocking 2003; Pitt & Hocking 2006)	Assessment not required	Assessment not required	Assessment not required	No
Aspergillus foetidus Thom & Raper [Eurotiales: Aspergillaceae]	Yes (Shah & Madamwar 2005)	Yes (Upsher & Upsher 1995)	Assessment not required	Assessment not required	Assessment not required	No

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Aspergillus fumigatus Fresen. [Eurotiales: Aspergillaceae]	Yes (Thilagam, Nayak & Nanda 2015)	Yes (Upsher & Upsher 1995)	Assessment not required	Assessment not required	Assessment not required	No
Aspergillus nidulans (Eidam) G. Winter [Eurotiales: Aspergillaceae]	Yes (Vyawahare et al. 2012)	Yes (Yip & Weste 1985)	Assessment not required	Assessment not required	Assessment not required	No
Aspergillus niger Tiegh. [Eurotiales: Aspergillaceae]	Yes (Pawar et al. 2008)	Yes (Leong 2005)	Assessment not required	Assessment not required	Assessment not required	No
Aspergillus niveus Blochwitz [Eurotiales: Aspergillaceae] (synonym: *Aspergillus neoniveus* Samson et al.)	Yes (Seth, Alam & Shukla 2016)	Yes (Daynes et al. 2012)	Assessment not required	Assessment not required	Assessment not required	No
Aspergillus tubingensis Mosseray [Eurotiales: Aspergillaceae]	Yes (Reddy et al. 2002)	Yes (Varga et al. 2004)	Assessment not required	Assessment not required	Assessment not required	No
Aspergillus variecolor Thom & Raper [Eurotiales: Aspergillaceae] (synonyms: *Aspergillus stellatus* Curzi)	Yes (Seth, Alam & Shukla 2016; Sharma, Roy & Singh 1981)	Yes (CSIRO 2019a)	Assessment not required	Assessment not required	Assessment not required	No
Aspergillus versicolor (Vuill.) Tirab. [Eurotiales: Aspergillaceae]	Yes (Sharma et al. 2011)	Yes (Fremlin et al. 2009)	Assessment not required	Assessment not required	Assessment not required	No

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Beltraniella humicola P. Rama Rao [Amphisphaeriales: Phlogicylindriaceae]	Yes (Gajbhiye et al. 2013)	Not known to occur	No: *Beltraniella humicola* is primarily a foliage pathogen on pomegranate (Thakur & Ram 2015) and is a secondary pest causing fruit spot on pomegranate (Sherkar & Utikar 1982). The fungus requires an injury to cause an infection. Damaged fruit and the visible symptoms caused by the pathogen would likely be identified on commercial fruit during quality checks and packing house practices and therefore removed from the pathway.	Assessment not required	Assessment not required	No
Botryosphaeria dothidea (Moug.) Ces. & De Not. [Botryosphaeriales: Botryosphaeriaceae]	Yes (Rao et al. 2011)	Yes (Qiu et al. 2008)	Assessment not required	Assessment not required	Assessment not required	No
Botryosphaeria rhodina (Berk. & M. A. Curtis) Arx [Botryosphaeriales: Botryosphaeriaceae] (synonyms: *Botryodiplodia theobromae* Pat.; *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl.)	Yes (Chandra, Jadhav & Sharma 2010; Rott et al. 2000)	Yes (Johnson et al. 1991)	Assessment not required	Assessment not required	Assessment not required	No
Botrytis cinerea Pers. [Heliotiales: Sclerotiniaceae]	Yes (Kaur & Chandel 2016)	Yes (Salam et al. 2011; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Ceratocystis fimbriata Ellis & Halst. [Microascales: Ceratocystidaceae]	Yes (Chandra, Jadhav & Sharma 2010)	No: *Ceratocystis fimbriata* has several apparently host-specialised strains known as 'types', 'races', or 'forms' (Baker et al. 2003; de Beer et al. 2014; Harrington 2000; Vogelzang & Scott 1990). *Ceratocystis fimbriata* isolates reported in Australia are all from *Syngonium* (Plant Health Australia 2020; Vogelzang & Scott 1990).	No: This fungus is a soil-borne pathogen and is associated with root-knot nematode (*Meloidgyne incognita*), causing pomegranate wilt (Kerakalamatti et al. 2019). *Ceratocystis fimbriata* was isolated from discoloured roots, stem, leaves and branch tissues of pomegranate (Somasekhara 1999; Somasekhara, Wali & Bagali 2000; Soni & Kanwar 2016). There is no reported evidence suggesting that this fungus is associated with pomegranate fruit.	Assessment not required	Assessment not required	No
Cercospora granati Rawla [Mycosphaerellales: Mycosphaerellaceae] (synonym: *Pseudocercosporella granati* (Rawla) Deighton)	Yes (Holland, Hatib & Bar-Ya'akov 2009)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Cercospora granati*. This species is associated with pomegranate leaves (Holland, Hatib & Bar-Ya'akov 2009).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cercospora lythracearum Heald & F. A. Wolf [Mycosphaerellales: Mycosphaerellaceae] (synonym: *Pseudocercospora lythracearum* (Heald & F. A. Wolf) X. J. Liu & Y. L. Guo)	Yes (Agarwal & Hasija 1964; Rangaswami & Mahadevan 1998)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Cercospora lythracearum*. This species is associated with pomegranate leaves (Blake & Williamson 2015; Rangaswami & Mahadevan 1998).	Assessment not required	Assessment not required	No
Ceuthospora phyllosticta C. Massal. [Phacidiales: Phacidiaceae]	Yes (Jamadar et al. 2011)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Ceuthospora phyllosticta*. This species is associated with pomegranate twigs (Jamadar et al. 2011; Verma & Sharma 1999).	Assessment not required	Assessment not required	No
Chaetomella raphigera Swift [Helotiales: Chaetomellaceae]	Yes (Gajbhiye et al. 2016)	Yes (ALA 2020)	Assessment not required	Assessment not required	Assessment not required	No
Chaetomium globosum Kunze [Sordariales: Chaetomiaceae]	Yes (Gond et al. 2007)	Yes (Syed et al. 2009)	Assessment not required	Assessment not required	Assessment not required	No
Cladosporium cladosporioides (Fresen.) G. A. de Vries [Capnodiales: Cladosporiaceae]	Yes (Farr & Rossman 2018)	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
Cladosporium herbarum (Pers.) Link [Capnodiales: Cladosporiaceae]	Yes (Swer, Dkhar & Kayang 2011)	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cladosporium oxysporum Berk. & M. A. Curtis [Capnodiales: Cladosporiaceae]	Yes (Ploetz et al. 2003)	Yes (Wilingham et al. 2002)	Assessment not required	Assessment not required	Assessment not required	No
Cladosporium tenuissimum Cooke [Capnodiales: Cladosporiaceae]	Yes (Verma, Sharma & Soni 2008)	Yes (Fisher, Petrini & Sutton 1993)	Assessment not required	Assessment not required	Assessment not required	No
Cochliobolus lunatus R. R. Nelson & F. A. Haasis [Pleosporales: Pleosporaceae] (synonym: *Curvularia lunata* (Wakker) Boedijn)	Yes (Louis et al. 2013)	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
Coleophoma empetri (Rostr.) Petr. [Incertae sedis: Incertae sedis]	Yes (Sherkar, Utikar & More 1980)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Coleophoma empetri*. This species is associated with pomegranate fruit (Sherkar, Utikar & More 1980).	Yes: *Coleophoma empetri* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Chitambar 2016; Farr & Rossman 2019). Spread of this fungus from the fruit pathway to a suitable host in Australia will depend on survival, production of inoculum, and availability of a susceptible host.	Yes: *Coleophoma empetri* has the potential for economic consequences in Australia. This species causes field and storage rot in cranberries. It occurs as part of a fungal complex of 15 or more species (Wells, Perry & McManus 2014) which resulted in 100% crop loss in cranberries in New Jersey, USA prior to the introduction of fungicides (Johnson-Cicalese et al. 2015; Oudemans, Caruso & Stretch 1998).	Yes

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. [Glomerellales: Glomerellaceae]	Yes (Chandra, Jadhav & Sharma 2010)	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
Coniella granati (Sacc.) Petr. & Syd. [Diaporthales: Schizoparmaceae] (synonyms: *Phoma granati* Sacc., *Phomopsis versoniana* (Sacc.) Mussat)	Yes (Keane et al. 2000; Sharma & Jain 1978)	Yes (Plant Health Australia 2020)	Assessment not required	Assessment not required	Assessment not required	No
Curvularia pallescens Boedijn [Pleosporales: Pleosporaceae]	Yes (Chandra, Jadhav & Sharma 2010)	Yes (Keane et al. 2000; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
Curvularia verruculosa Tandon & Bilgrami ex M. B. Ellis [Pleosporales: Pleosporaceae]	Yes (Manamgoda et al. 2015)	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
Diplodia seriata De Not. [Botryosphaeriales: Botryosphaeriaceae] (synonym: *Botryosphaeria obtusa* (Schwein.) Shoemaker)	Yes (Dar & Rai 2017)	Yes (Taylor et al. 2005)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Discosia punicae Shreem. & M. Reddy [Amphisphaeriales: Discosiaceae] (synonym: *Monochaetia punicae* (Shreem. & M. Reddy) Vanev)	Yes (Chandra, Jadhav & Sharma 2010)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Discosia punicae*. This species is associated with pomegranate leaves (Holland, Hatib & Bar-Ya'akov 2009; Sharma 2012).	Assessment not required	Assessment not required	No
Elsinoë punicae (Bitanc. & Jenkins) Rossman & W.C. Allen [Myriangiales: Elsinoaceae] (synonym: *Sphaceloma punicae* Bitanc. & Jenkins) Pomegranate scab	Yes (Rangaswami & Mahadevan 1998)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Elsinoë punicae*. This species is associated with pomegranate fruit (Prasad, Chandra & Teixeira da Silva 2010; Reddy 2010; Yehia 2013).	Yes: *Elsinoë punicae* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Farr & Rossman 2018). Spread of this fungus from the fruit pathway to a suitable host in Australia will depend on pathogen survival, production of inoculum, and availability of a susceptible host.	Yes: *Elsinoë punicae* has the potential for economic consequences in Australia. This species causes scab-like symptoms on the fruit and brown spots on the leaves rendering fruit unmarketable (Carstens et al. 2018). In India, fruit spots caused by *Elsinoë punicae* can have an incidence of up to 100% (ICAR 2012).	Yes
Erysiphe punicae T. M. Achundov [Erysiphales: Erysiphaceae]	Yes (Farr & Rossman 2018; Hosagoudar 2013)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Erysiphe punicae*. This species is associated with pomegranate leaves (Hosagoudar 2013).	Assessment not required	Assessment not required	No
Exserohilum rostratum (Drechsler) K. J. Leonard & Suggs [Pleosporales: Pleosporaceae]	Yes (Keane et al. 2000)	Yes (Irwin et al. 1999; Leslie 2008)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Fusarium chlamydosporum Wollenw. & Reinking [Hypocreales: Nectriaceae] (synonyms: *Fusarium fusarioides* (Gonz. Frag. & Cif.) C. Booth)	Yes (Chadha, Prasad & Varma 2015)	Yes (Summerell et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No
Fusarium oxysporum Schltdl. [Hypocreales: Nectriaceae]	Yes (Chandra, Jadhav & Sharma 2010)	Yes (Elmer et al. 1997; Irwin et al. 1999; Summerell et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No
Fusarium solani (Mart.) Sacc. [Hypocreales: Nectriaceae]	Yes (Chandra, Jadhav & Sharma 2010)	Yes (Pegg et al. 2002; Sangalang et al. 1995; Summerell et al. 2011)	Assessment not required	Assessment not required	Assessment not required	No
Fusicoccum aesculi Corda [Botryosphaeriales: Botryosphaeriaceae] (synonyms: *Neofusicoccum ribis* (Slippers, Crous & Wingf.) Crous, Slippers & Phillips; *Botryosphaeria ribis* Grossenb. & Duggar)	Yes (Anahosur & Fazalnoor 1972)	Yes (Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
Julella multiloculata A. Pande & V. G. Rao [*Incertae sedis*: Thelenellaceae]	Yes (Pande & Rao 1989)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Julella multiloculata*. This species is associated with pomegranate twigs (Pande & Rao 1989).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Leptosphaeria punicae A. K. Kar & Maity [Pleosporales: Leptosphaeriaceae]	Yes (Kar & Maity 1970)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Leptosphaeria punicae*. This species is associated with pomegranate branches (Kar & Maity 1970).	Assessment not required	Assessment not required	No
Macrophomina phaseolina (Tassi) Goid. [Botryosphaeriales: Botryosphaeriaceae] (synonym: *Macrophoma phaseolina* Tassi)	Yes (Farr & Rossman 2018)	Yes (Fuhlbohm, Ryley & Aitken 2012; Shivas 1989; Walker 1994)	Assessment not required	Assessment not required	Assessment not required	No
Neofusicoccum parvum (Pennycook & Samuels) Crous, Slippers & A. J. L. Phillips [Botryosphaeriales: Botryosphaeriaceae]	Yes (Jayakumar, Rajalakshmi & Amaresan 2011)	Yes (Sakalidis et al. 2013)	Assessment not required	Assessment not required	Assessment not required	No
Nigrospora oryzae (Berk. & Broome) Petch [Incertae sedis: Incertae sedis]	Yes (Chandra, Jadhav & Sharma 2010)	Yes (Cullen, Julien & McFadyen 2012; Irwin et al. 1999)	Assessment not required	Assessment not required	Assessment not required	No
Nitschkia punicae (Bale) A. Pande [Coronophorales: Nitschkiaceae] (synonym: *Tympanopsis punicae* Bale)	Yes (Bale 1983; Farr & Rossman 2018)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Nitschkia punicae*. This species is associated with dried pomegranate stems (Bale 1983).	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Passalora legrellei (V. G. Rao & B. R. D. Yadav) Kamal [Mycosphaerellales: Mycosphaerellaceae] (synonym: *Phaeoramularia legrellei* V. G. Rao & B. R. D. Yadav)	Yes (Farr & Rossman 2018; Rao & Yadav 1991)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Passalora legrellei*. This species is associated with pomegranate leaves (Rao & Yadav 1991).	Assessment not required	Assessment not required	No
Penicillium atramentosum Thom [Eurotiales: Trichocomaceae]	Yes (Jandial & Sumbali 2011)	Yes (Yu, Sang & Park 2015)	Assessment not required	Assessment not required	Assessment not required	No
Penicillium expansum Link [Eurotiales: Trichocomaceae]	Yes (Rao et al. 2011)	Yes (Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
Penicillium glabrum (Wehmer) Westling [Eurotiales: Trichocomaceae]	Yes (Chauhan et al. 2013)	Yes (Fisher, Petrini & Sutton 1993; Hyde 1996)	Assessment not required	Assessment not required	Assessment not required	No
Penicillium herquei Bainier & Sartory [Eurotiales: Trichocomaceae]	Yes (Zakir & Sharma 2009)	Yes (CSIRO 2019a)	Assessment not required	Assessment not required	Assessment not required	No
Penicillium implicatum Biourge [Eurotiales: Trichocomaceae]	Yes (Panda 2011)	Yes (Pitt & Hocking 2009)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Penicillium purpurogenum Stoll [Eurotiales: Trichocomaceae]	Yes (Avasthi, Gautam & Bhadauria 2015)	Yes (Dewan & Sivasithamparam 1988)	Assessment not required	Assessment not required	Assessment not required	No
Penicillium sclerotiorum Beyma [Eurotiales: Aspergillaceae]	Yes (Gehlot & Singh 2018)	Yes (Rivera & Seifert 2011)	Assessment not required	Assessment not required	Assessment not required	No
Pestalotia jodhpurensis Bilgrami & Purohit [Amphisphaeriales: Amphisphaeriaceae]	Yes (Farr & Rossman 2018)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Pestalotia jodhpurensis*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Pestalotiopsis versicolor (Speg.) Steyaert [Amphisphaeriales: Pestalotiopsidaceae]	Yes (Chandra, Jadhav & Sharma 2010)	Yes (Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
Phaeoacremonium italicum Carlucci & Raimondo [Togniniales: Togniniaceae]	Yes (Singh et al. 2016)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Phaeoacremonium italicum*. This species is associated with pomegranate wood (Spies et al. 2018).	Assessment not required	Assessment not required	No
Phaeoacremonium parasiticum (Ajello, Georg & Wang) Gams, Crous & Wingf. [Togniniales: Togniniaceae]	Yes (Premalatha et al. 2014)	Yes (Gramaje et al. 2014)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Phoma punicae M. P. Srivast, Tandon, Bhargava & A. K. Ghosh [Pleosporales: Didymellaecae]	Yes (Srivastava et al. 1966)	Not known to occur	No: The fungus is a postharvest pathogen. The fungus was first reported on twigs in 1966 (Srivastava et al. 1966) and then reported in 1983 causing postharvest fruit rot in India on pomegranate (Somawane 1983). The isolated record and limited incidence of this fungus as reported in India, absence of further records of this fungus on pomegranate and the packing house practices in place to mitigate postharvest infection, including inspection, cleaning and sanitation indicate that this pathogen is unlikely to be on the pathway.	Assessment not required	Assessment not required	No
Phomopsis aucubicola (Brunaud) Grove [Diaporthales: Diaporthaceae]	Yes (Khosla & Gupta 2014)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Phomopsis aucubicola*. This species is associated with pomegranate leaves and fruit (Khosla & Bhardwaj 2013; Khosla & Gupta 2014).	No: *Phomopsis aucubicola* is unlikely to establish and spread in Australia. Pomegranate is the only reported host for this fungus (Department of Agriculture Himachal Pradesh 2020; Khosla & Gupta 2015). A lack of literature on the occurrence of this fungus in India's major pomegranate growing areas, and isolated reports of its limited distribution in India suggest that it does not have the potential for establishment and spread.	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Physcia stellaris (L.) Nyl. [Teloschistales: Physciaceae] (synonym: *Physcia jackii* Moberg)	Yes (Logesh et al. 2015)	Yes (Elix, Corush & Lumbsch 2009; Galloway & Moberg 2005)	Assessment not required	Assessment not required	Assessment not required	No
Phytophthora nicotianae Breda de Haan [Peronosporales: Peronosporaceae]	Yes (Khosla & Gupta 2014)	Yes (Barber et al. 2013; Irwin et al. 1999; Stukely et al. 2007)	Assessment not required	Assessment not required	Assessment not required	No
Phytophthora palmivora (E. J. Butler) E. J. Butler [Peronosporales: Peronosporaceae]	Yes (Farr & Rossman 2018)	Yes (Barber et al. 2013; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
Pseudocercospora punicae (Henn.) Deighton [Mycosphaerellales: Mycosphaerellaceae] (synonym: *Cercospora punicae* Henn.) Cercospora fruit spot	Yes (Chandra, Jadhav & Sharma 2010; Rangaswami & Mahadevan 1998)	Not known to occur	Yes: Pomegranate fruit provides a pathway for *Pseudocercospora punicae*. This species is associated with pomegranate fruit (Phengsintham et al. 2011; USDA 2010).	Yes: *Pseudocercospora punicae* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Mycobank 2016; Phengsintham et al. 2011). Spread of this fungus from the fruit pathway to a suitable host in Australia will depend on survival, production of inoculum, and availability of a susceptible host. This species may be able to access hosts in the environment via wind dispersal (Reddy 2010).	Yes: *Pseudocercospora punicae* has the potential for economic consequences in Australia. This species causes black spots on fruit and leaves, reducing yield and rendering fruit unmarketable (Phengsintham et al. 2011). In India, fruit spots caused by *Pseudocercospora punicae* can have an incidence of up to 32% (ICAR 2012; Khosla & Bhardwaj 2013).	Yes

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Punctelia borreri (Sm.) Krog [Lecanorales: Parmeliaceae] (Synonym: *Parmelia borreri* (Sm.) Turner)	Yes (Rawat, Upreti & Singh 2011)	Yes (Kantvilas, Howe & Elix 1996; Whiting 2014)	Assessment not required	Assessment not required	Assessment not required	No
Rhizoctonia solani JG Kühn [Cantharellales: Ceratobasidiaceae]	Yes (Bernardes-de-Assis et al. 2009)	Yes (Anderson et al. 2004; Cook & Dubé 1989)	Assessment not required	Assessment not required	Assessment not required	No
Rhizopus arrhizus A. Fisch. [Mucorales: Rhizopodaceae]	Yes (Acton 2012; Singh & Chohan 1974)	Yes (Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
Rhizopus stolonifer (Ehrenb.) Vuill. [Mucorales: Rhizopodaceae]	Yes (Anbu, Hilda & Gopinath 2004; Ganaie et al. 2010)	Yes (Cook & Dubé 1989; Irwin et al. 1999)	Assessment not required	Assessment not required	Assessment not required	No
Rhytidhysteron rufulum (Spreng.) Speg. [Patellariales: Patellariaceae] (Synonym: *Tryblidiella rufula* var. *microspora* Rehm)	Yes (Almeida, Gusmão & Miller 2014; Rao 1969)	Yes (Galea 2013; Yuan 1996)	Assessment not required	Assessment not required	Assessment not required	No
Rosellinia necatrix Berl. ex Prill [Xylariales: Xylariaceae]	Yes (Ciancio & Mukerji 2008; Sharma & Sharma 2002)	Yes (Stephens 2003)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Rosellinia punicae Anahosur [Xylariales: Xylariaceae]	Yes (Bhise & Reddy 2013)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Rosellinia punicae*. This species is associated with pomegranate dead twigs (Bhise & Reddy 2013).	Assessment not required	Assessment not required	No
Sclerotium rolfsii Sacc. [Atheliales: Atheliaceae] (synonym: *Athelia rolfsii* Curzi)	Yes (Chandra, Jadhav & Sharma 2010; Sarma, Singh & Singh 2002)	Yes (Cook & Dubé 1989; Irwin et al. 1999)	Assessment not required	Assessment not required	Assessment not required	No
Sphaeropsis punicae Shreem. & Bilgrami [Botryosphaeriales: Botryosphaeriaceae]	Yes (Farr & Rossman 2018)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Sphaeropsis punicae*. This species is associated with pomegranate leaves (USDA 2010).	Assessment not required	Assessment not required	No
Setosphaeria rostrata K. J. Leonard [Pleosporales: Pleosporaceae] (synonym: *Exserohilum rostratum* (Drechsler) K. J. Leonard & Suggs)	Yes (Holland, Hatib & Bar-Ya'akov 2009)	Yes (Lehmensiek et al. 2010)	Assessment not required	Assessment not required	Assessment not required	No
Syncephalastrum racemosum Cohn ex J. Schröt. [Mucorales: Syncephalastraceae]	Yes (Lodha, Gupta & Singh 1986)	Yes (Yuan et al. 1997)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Thielavia appendiculata M. P. Srivast., Tandon, Bhargava & A. K. Ghosh [Sordariales: Chaetomiaceae]	Yes (Firdousi, Rai & Vyas 1990)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Thielavia appendiculata*. This species is associated with pomegranate leaves (Srivastava et al. 1966).	Assessment not required	Assessment not required	No
Verticillium dahliae Kleb. [Glomerellales: Plectosphaerellaceae]	Yes (Sivaprakasam & Rajagopalan 1974)	Yes (Puhalla & Hummel 1983)	Assessment not required	Assessment not required	Assessment not required	No
Xanthoria parietina (L.) Th. Fr. [Teloschistales: Teloschistaceae]	Yes (Shukla, Upreti & Bajpai 2014)	Yes (Meier, Scherrer & Honegger 2002)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
VIROIDS						
Hop stunt viroid (HSVd) [Pospiviroidae: Hostuviroid]	Yes (Roy & Ramachandran 2003)	Yes (Koltunow, Krake & Rezaian 1988). Listed as a Declared Organism (Prohibited (section 12)) for WA (Government of Western Australia 2018)	Yes: Pomegranate fruit provides a pathway for HSVd. This viroid has been detected in pomegranate leaves (Gazel et al. 2009; Gorsane et al. 2010; Onelge 2000); however, as HSVd infects systemically (Flores et al. 2005; Li et al. 2006), it is likely the species is associated with pomegranate fruit and seeds.	No: *Hop stunt viroid* is unlikely to establish and spread in Australia. Currently there are no known natural vectors of HSVd (European Food Safety Authority 2008). As a result, the transfer of HSVd from an imported infected pomegranate fruit to a susceptible host via a vector would not occur through natural mechanisms. HSVd has been demonstrated to be seed transmitted in grapes (Wan Chow Wah & Symons 1999); however, no published literature is available to suggest that this species is seed transmitted in pomegranate. HSVd is principally transmitted via mechanical means, and through grafting (European Food Safety Authority 2008); however, transfer via grafting, cutting or pruning tools from imported pomegranate fruit is unlikely in either a domestic or commercial context.	Assessment not required	No
VIRUSES						
Cucumber mosaic virus (CMV) [Bromoviridae: Cucumovirus]	Yes (Bhat, Hareesh & Madhubala 2005; Verma et al. 2004)	Yes (Alberts, Hannay & Randles 1985; Persley, Cooke & House 2010)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Grapevine leafroll-associated virus 1 [Closteroviridae: Closterovirus]	Yes (Kumar et al. 2012; Kumar et al. 2013b)	Yes (Habili, Fazeli & Rezaian 1997)	Assessment not required	Assessment not required	Assessment not required	No
Tomato ringspot virus (ToRSV) [Secoviridae: Nepovirus]	Yes (Rana et al. 2011)	Not known to occur	No: Pomegranate fruit does not provide a pathway for *Tomato ringspot virus*. This species is associated with pomegranate leaves (EPPO 2015b).	Assessment not required	Assessment not required	No
PHYTOPLASMA						
'*Candidatus* Phytoplasma asteris' [16SrI] (Aster yellows group)	Yes (Chaturvedi et al. 2010; Singh et al. 2014)	Not known to occur	No: Pomegranate fruit does not provide a pathway for '*Candidatus* Phytoplasma asteris'. This phytoplasma is associated with pomegranate leaves (Gazel et al. 2016).	Assessment not required	Assessment not required	No
'*Candidatus* Phytoplasma australasia' [16SrII-D] (Peanut witches' broom group)	Yes (Singh et al. 2012)	Yes (Hodgetts et al. 2008)	Assessment not required	Assessment not required	Assessment not required	No
'*Candidatus* Phytoplasma pruni' [16SrIII] (X-disease group)	Yes (Singh et al. 2011)	Not known to occur	No: Pomegranate fruit does not provide a pathway for '*Candidatus* Phytoplasma pruni'. This phytoplasma is associated with pomegranate leaves (Karimi et al. 2015).	Assessment not required	Assessment not required	No

Appendix A-2: Pests of pomegranate fruit that are assessed for pomegranate processed arils from India for human consumption

The pests of biosecurity concern associated with pomegranate fruit from India are provided in (Appendix A-1). India has also requested access for commercially produced arils (section 3.6); therefore, the department has undertaken an assessment of pathway (in this case, commercially produced pomegranate arils) to identify association of any quarantine pest of pomegranate fruit, requiring specific measures for processed arils. The outcome of this assessment is provided in Appendix A-2.

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
ARTHROPODS						
ACARI (mites)						
Tenuipalpus granati Sayed 1946 [Acari: Tenuipalpidae] Pomegranate mite	Yes (Balikai, Kotikal & Prasanna 2009; Çobanoğlu, Ueckermann & Sağlam 2016)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Tenuipalpus granati*. This species is an external feeder and associated with pomegranate leaves, flowers and fruit (Ananda, Kotikal & Balikai 2009; Jeppson, Keifer & Baker 1975; USDA 2017). There is no reported evidence that these mites are associated with internal parts of pomegranate fruit, including arils. Packing house processes, including washing, hand brushing of individual fruit and removal of calyx before aril extraction and fruit waste management practices will minimise the likelihood of these mites contaminating arils.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Tenuipalpus punicae Pritchard & Baker 1958 [Acari: Tenuipalpidae] Pomegranate false spider mite	Yes (Balikai, Kotikal & Prasanna 2009; Çobanoğlu, Ueckermann & Sağlam 2016)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Tenuipalpus punicae*. This species is an external feeder and associated with pomegranate leaves and fruit (Al-Gboory & El-Haidari 1988; Cocuzza et al. 2016; Holland, Hatib & Bar-Ya'akov 2009; Jeppson, Keifer & Baker 1975). There is no reported evidence that these mites are associated with internal parts of pomegranate fruit, including arils. Packing house processes, including washing, hand brushing of individual fruit and removal of calyx before aril extraction and fruit waste management practices will minimise the likelihood of these mites contaminating arils.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
DIPTERA						
Bactrocera carambolae Drew & Hancock 1994 [Diptera: Tephritidae] Carambola fruit fly	Yes (CABI 2018; Kapoor 2002). Only reported to occur in the Andaman and Nicobar Islands (Kapoor 2005; PHA 2018)	Not known to occur	Yes: Pomegranate arils provide a pathway for *B. carambolae*. This species is associated with pomegranate fruit (CABI 2020). The introduction of *B. carambolae* to South America has been linked to the small-scale trade of fruits from Indonesia (Marchioro 2016). Eggs are laid below the rind of the host fruit in which larvae feed (CABI 2020). The small sized (0.2mm x 0.8mm) eggs among arils are unlikely to be detected during arils production. The proposed storage (0°C to 2°C) and transport (1°C to 5°C) temperatures are unlikely to be lethal to eggs and larvae of *B. carambolae*.	Yes: *Bactrocera carambolae* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Marchioro 2016; van Sauers-Muller 2005). Any areas with hot and humid climates or extremely hot and arid areas are potential establishment sites for this fruit fly (Marchioro 2016). Importation of infested commodity from one area to another is an important means of introduction and spread of fruit flies. Fruit flies are strong flyers (Fletcher 1989); therefore, adult flight and the transport of infected arils could assist the spread of *Bactrocera carambolae* in Australia.	Yes: *Bactrocera carambolae* has the potential for economic consequences in Australia. This species is highly polyphagous, feeding on over 100 host plants including avocado, lemon, orange and mango (Marchioro 2016). Estimates indicate that the spread of *B. carambolae* throughout Brazil may result in economic losses of US$ 30.7 million in the first year (Marchioro 2016). Consequences would include crop losses as well as quarantine restrictions on trade, both within Australia and internationally to areas where this species is not present.	Yes (EP)

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Bactrocera dorsalis Hendel 1912 [Diptera: Tephritidae] (synonym: *Bactrocera invadens* Drew, Tsuruta & White 2005) Oriental fruit fly	Yes (Balikai, Kotikal & Prasanna 2009)	No: Eradicated from mainland Australia (Hancock et al. 2000)	Yes: Pomegranate arils provide a pathway for *Bactrocera dorsalis*. This species is associated with pomegranate fruit (Jose, Cugala & Santos 2013). *Bactrocera dorsalis* larva was detected in a commercial shipment of pomegranate arils from India in the USA in 2018, indicating that this fruit fly is present on the pathway. Adults lay 1–20 eggs in a single fruit in which larvae feed (FDACS 2017). The small sized (0.2mm x 0.8mm) eggs among arils are unlikely to be detected during arils production. The proposed storage (0°C to 2°C) and transport (1°C to 5°C) temperatures are unlikely to be lethal to eggs and larvae of *B. dorsalis*.	Yes: *Bactrocera dorsalis* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (De Villiers et al. 2015). Importation of infested commodity from one area to another is an important means of introduction and spread of fruit flies. Fruit flies are strong flyers (Fletcher 1989); therefore, adult flight and the transport of infected arils could assist the spread of *Bactrocera dorsalis* in Australia. After introduction, it can easily spread as it has high reproductive potential and high biotic potential (short life cycle, up to 10 generations of offspring per year depending on temperature), a rapid dispersal ability (can fly 50km to 100km) and a broad host range (Duyck, Sterlin & Quilici 2004; IPPC 2017b; Sridhar et al. 2014).	Yes: *Bactrocera dorsalis* has the potential for economic consequences in Australia. This species is highly polyphagous, feeding on over 150 host plants (Allwood et al. 1999). Without control, direct damage of up to 100% has been reported on mango in Africa (Nankinga et al. 2014). Guava crops in India have reported crop losses of up to 70% (Verghese et al. 2002). Consequences would include crop losses as well as quarantine restrictions on trade, both within Australia and internationally to areas where this species is not present.	Yes (EP)

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Bactrocera zonata Saunders 1842 [Diptera: Tephritidae] (synonym: *Dacus zonatus* Saunders 1842) Peach fruit fly	Yes (Allwood et al. 1999; Balikai, Kotikal & Prasanna 2009)	Not known to occur	Yes: Pomegranate arils provide a pathway for *Bactrocera zonata*. This species is associated with pomegranate fruit (Alzubaidy 2000). This fruit fly can also be transported in fruit packaging material (EPPO 2015a). Eggs of related species are laid below the rind of the host fruit in which larvae feed (CDFA 2018). The small sized (0.2mm x 1.0mm to 1.2mm) eggs among arils are unlikely to be detected during arils production. The proposed storage (0°C to 2°C) and transport (1°C to 5°C) temperatures are unlikely to be lethal to eggs and larvae of *B. zonata*.	Yes: *Bactrocera zonata* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Alzubaidy 2000). *Bactrocera zonata* is mainly a tropical species and areas with an upper temperature limit of 35°C are potential establishment sites (Duyck, Sterlin & Quilici 2004). Importation of infested commodity from one area to another is an important means of introduction and spread of fruit flies. *Bactrocera zonata* is a strong flyer (Qureshi et al. 1974) and readily disperses as far as 40 km, even when hosts are abundant (Fletcher 1989; Qureshi et al. 1974).	Yes: *Bactrocera zonata* has the potential for economic consequences in Australia. This species is highly polyphagous, feeding on over 50 host plants (Alzubaidy 2000; EPPO 2015a). The estimated annual cost of *B. zonata* in Egypt is over US$ 177 million (Alzubaidy 2000). Extensive crop losses have been reported in Asia (25% to 100%) and the Middle East (30% to 50%) (Alzubaidy 2000; Mahmoud et al. 2017). Consequences would include crop losses as well as quarantine restrictions on trade, both within Australia and internationally to areas where this species is not present.	Yes (EP)

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
HEMIPTERA						
Aphis punicae Passerini 1863 [Hemiptera: Aphididae] Pomegranate aphid	Yes (Balikai, Kotikal & Prasanna 2009; Sreedevi & Verghese 2007b)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Aphis punicae*. This species is associated with pomegranate fruit, tender shoots, flower buds and flowers (Ananda 2007; Cocuzza et al. 2016; Sreedevi et al. 2006). This aphid is an external feeder and there is no reported evidence of this aphid to be associated with the internal parts of pomegranate fruit, including arils. Packing house processes, including washing, hand brushing of individual fruit, removal of calyx before aril extraction, and fruit waste management practices will minimise the likelihood of this aphid contaminating arils.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Drosicha dalbergiae (Stebbing 1902) [Hemiptera: Monophlebidae] Almond mealy bug	Yes (Rawat, Pawar & Chand 1989; Varshney, Jadhav & Sharma 2015)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Drosicha dalbergiae.* This species is associated externally with pomegranate fruit (Rawat, Pawar & Chand 1989; USDA 2010). *Drosicha dalbergiae* is an external feeder and there is no reported evidence of this scale insect to be associated with the internal parts of pomegranate fruit, including arils. Packing house processes, including washing, hand brushing of individual fruit, removal of calyx before aril extraction, and fruit waste management practices will minimise the likelihood of this scale insect contaminating arils.	Assessment not required	Assessment not required	No
Dysmicoccus neobrevipes Beardsley 1959 [Hemiptera: Pseudococcidae] Grey pineapple mealybug; Annona mealybug	Yes (Mani, Smitha & Najitha 2016)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Dysmicoccus neobrevipes*. This species is associated with pomegranate fruit (USDA 2010). *Dysmicoccus neobrevipes* is an external feeder and there is no reported evidence that *D. neobrevipes* is associated with internal parts of pomegranate fruit, including arils. Packing house processes, including washing, hand brushing of individual fruit, removal of calyx before aril extraction and fruit waste management practices will minimise the likelihood of this mealybug contaminating arils.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Paracoccus marginatus Williams & Granara de Willink 1992 [Hemiptera: Pseudococcidae] Papaya mealybug	Yes (Muniappan et al. 2008)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Paracoccus marginatus*. This species is associated with pomegranate fruit (Sakthivel et al. 2012). *Paracoccus marginatus* is an external feeder and there is no reported evidence that *P. marginatus* is associated with internal parts of pomegranate fruit, including arils. Packing house processes, including washing, hand brushing of individual fruit, removal of calyx before aril aextraction, and fruit waste management practices will minimise the likelihood of this mealybug contaminating arils.	Assessment not required	Assessment not required	No
Planococcus ficus Signoret 1875 [Hemiptera: Pseudococcidae] Vine mealybug	Yes (Suroshe et al. 2016; Walton 2003)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Planococcus ficus*. This species is associated with pomegranate fruit and leaves (Miller et al. 2014; Suroshe et al. 2016). *Planococcus ficus* is an external feeder and there is no reported evidence that *P. ficus* is associated with internal parts of pomegranate fruit, including arils. Packing house processes, including washing, hand brushing of individual fruit, removal of calyx before aril extraction, and fruit waste management practices will minimise the likelihood of this mealybug contaminating arils.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Cryptoblabes gnidiella Millière 1867 [Lepidoptera: Pyralidae] Honeydew moth	Yes (Molet 2013; Sellanes, Rossini & González 2010)	Not known to occur	No: Pomegranate arils do not provide a pathway for *C. gnidiella*. This species is associated with pomegranate fruit (Avidov & Harpaz 1969b; Carter 1984), and is primarily a secondary pest infesting fruits that are already damaged by other arthropod pests. This species is particularly attracted to sugary substances such as honeydew produced by mealybugs (Avidov & Harpaz 1969a; Ioriatti, Lucchi & Varela 2012) and show obvious signs of infestations that are readily identified during arils production. Damaged fruit would be identified on commercial fruit during quality checks and packing house practices and therefore removed from the pathway. The fruit waste management practices will minimise the likelihood of reinfestation of extracted arils by *C. gnidiella*.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Deudorix epijarbas Moore 1858 [Lepidoptera: Lycaenidae] Lycaenid fruit borer; Cornelian butterfly	Yes (Kumar 2014)	Yes (Braby & Douglas 2004; Nielsen, Edwards & Rangsi 1996). Listed as a Declared Organism (Prohibited (section 12)) for WA (Government of Western Australia 2018)	Yes: Pomegranate arils provide a pathway for *Deudorix epijarbas*. This species is associated with pomegranate fruit (Hill 1987). *Deudorix epijarbas* larvae bore into the fruit and feed upon the pulp and seeds (Thakur et al. 1995). *Deudorix epijarbas* attacks pomegranate fruit from early stages through to maturity (Mohi-Ud-Din et al. 2015). First instar larvae are of about 4mm long and 0.9mm wide on average (Mallikarjun & Pal 2018; Mohi-ud-din 2014) and light brown in colour. The entry hole on the fruit of the first instar larvae may go undetected during packing house processes and there is a possibility that first instar larvae could be present in extracted arils.	Yes: *Deudorix epijarbas* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in Queensland, Indonesia, Papua New Guinea, Solomon Islands and Oriental Region (Edwards, Newland & Regan 2001). This species is polyphagous, feeding on several host plants (Braby 1997; Hill 2008; Loc, Kumar & Chakravarthy 2018; Waite & Hwang 2002; Zaka-Ur-Rab 1980). Some of these hosts are widespread in Australia. The flying adults of this species are able to disperse independently to find suitable hosts.	Yes: *Deudorix epijarbas* has the potential for economic consequences in Australia. *Deudorix epijarbas* caterpillars can significantly reduce yields in pomegranate (Chauhan & Kanwar 2012). In India, reports have been made of *Deudorix epijarbas* infestations of up to 60% in pomegranate (Gupta & Dubey 2005).	Yes (WA)

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Deudorix isocrates Fabricius 1793 [Lepidoptera: Lycaenidae] (synonym: *Virachola isocrates* Fabricius) Common guava blue; Pomegranate butterfly	Yes (Bagle 2011; Balikai, Kotikal & Prasanna 2009)	Not known to occur	Yes: Pomegranate arils provide a pathway for *Deudorix isocrates*. This species is associated with pomegranate fruit, stalks and leaves (Chhetry, Gupta & Tara 2015; Kumar 2014). *Deudorix isocrates* bore into fruit and feed upon the pulp and seeds (Chhetry, Gupta & Tara 2015; Kumar 2014; Kumar et al. 2017). First instar larvae are of about 1.5mm long and 0.9mm wide on average (Mallikarjun & Pal 2018) and creamy white in colour. The entry hole on the fruit of the first instar larvae may go undetected during packing house processes and there is a possibility that first instar larvae could be present in extracted arils.	Yes: *Deudorix isocrates* has the potential to establish and spread in Australia as suitable hosts and environments are available. This species has established in areas with a wide range of climatic conditions (Kumar 2014). The flying adults of this species are able to disperse independently to find suitable hosts.	Yes: *Deudorix isocrates* has the potential for economic consequences in Australia. In India, reports have been made of *Deudorix isocrates* infestations of up to 90% in pomegranate (Bagle 2011) and up to 26.4% in guava (Rama Devi & Jha 2017), as well as up to 18% damage to oranges (Chhetry, Gupta & Tara 2015).	Yes

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
THYSANOPTERA						
Frankliniella occidentalis Pergande 1895 [Thysanoptera: Thripidae] Western flower thrips	Yes (CABI 2018; Tyagi & Kumar 2015)	Yes (Kirk & Terry 2003; Malipatil et al. 1993). Declared and Notifiable Pest in NT (DPIR 2018).	No: Pomegranate arils do not provide a pathway for *Frankliniella occidentalis*. This species is associated with pomegranate flowers (Liu et al. 2014; Wohlfarter, Giliomee & Venter 2010) and has been intercepted on pomegranate fruit imported into Australia from the USA. However, there is no reported evidence that *Frankliniella occidentalis* is acssociated with internal parts of pomegranate fruit. Packing house processes, including washing, hand brushing of individual fruit, removal of calyx before aril aextraction, and fruit waste management practices will minimise the likelihood of this thrips contaminating arils.	Assessment not required	Assessment not required	No
Scirtothrips dorsalis Hood 1919 [Thysanoptera: Thripidae] Chilli thrips	Yes (Balikai, Kotikal & Prasanna 2009; Tyagi & Kumar 2014)	Yes (Mound, Tree & Paris 2018) However, assessed as a vector of emerging quarantine tospoviruses (Australian Government Department of Agriculture and Water Resources 2017).	No: Pomegranate arils do not provide a pathway for *Scirtothrips dorsalis*. This species is associated with pomegranate fruit (Kumar & Vishwakarma 2018); however, there is no reported evidence that this species is associated with internal parts of pomegranate fruit. Packing house processes will remove the rind with any pest associated with it. Fruit waste management practices will minimise the likelihood of this thrips contaminating arils.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Scirtothrips oligochaetus Karny 1926 [Thysanoptera: Thripidae] (synonym: *Anaphothrips oligochaetus* Kerny 1926) Mangosteen thrips	Yes (Balikai, Kotikal & Prasanna 2009) (Balikai, Kotikal & Prasanna 2009; Chakraborty et al. 2019)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Scirtothrips oligochaetus*. This species is an external feeder, associated with pomegranate leaves, flowers and fruit (Ananda 2007; Balikai, Kotikal & Prasanna 2009) and there is no reported evidence that this species is associated with internal parts of pomegranate fruit. Packing house processes will remove the rind with any pest associated with it. Fruit waste management practices will minimise the likelihood of this thrips contaminating arils.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
BACTERIA						
Xanthomonas axonopodis pv. *punicae* (Hingorani & Singh 1959) Vauterin et al. 1995 [Xanthomonadales: Xanthomonadaceae] (synonyms: *Xanthomonas punicae* Chand & Kishun 1991; *Xanthomonas campestris* pv. *punicae* (Hingorani & Singh 1959) Dye 1978) Bacterial blight of pomegranate	Yes (Chandra, Jadhav & Sharma 2010; Sharma et al. 2017)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Xanthomonas axonopodis* pv. *punicae.* This species is associated with pomegranate fruit, twigs and leaves (Sharma et al. 2017). Infection produces obvious external symptoms, restricted to the rind, such as dark brown necrotic lesions, cracks and splitting of the entire fruit (Janse 2012a; Munhuweyi et al. 2016; Sharma 2012), making an infected fruit readily detected during packing house processes, which will not be used for aril production. The bacterium is reported to be only present as local lesions (Sharma et al. 2017) and no reported evidence that this bacterium is associated with arils or causes asymptomatic infections. Packing house processes will remove the rind and the bacterium associated with it.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
FUNGI						
Coleophoma empetri (Rostr.) Petr. [Incertae sedis: Incertae sedis]	Yes (Sherkar, Utikar & More 1980)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Coleophoma empetri*. This species is associated with pomegranate fruit (Sherkar, Utikar & More 1980). The infection is reported to be confined to the fruit rind with symptoms of brown spots, which coalesce into hard, depressed lesions appearing on the fruit rind (Sherkar, Utikar & More 1980). There is no reported evidence that this fungus is associated with internal parts of pomegranate fruit, including arils. Packing house processes will remove the rind with the pathogen associated with it.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Elsinoë punicae (Bitanc. & Jenkins) Rossman & W.C. Allen [Myriangiales: Elsinoaceae] (synonym: *Sphaceloma punicae* Bitanc. & Jenkins) Pomegranate scab	Yes (Rangaswami & Mahadevan 1998)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Elsinoë punicae*. This species is associated with pomegranate fruit (Prasad, Chandra & Teixeira da Silva 2010; Reddy 2010; Yehia 2013). The fungus causes irregular, brown to black lesions which harden with age forming slightly raised, wart-like outgrowths (scab lesions/pustules) on the rind (Thieumalachar 1946). The peel may crack or split due to scab lesions resulting in severe external disfigurement of the pomegranate fruit (Thieumalachar 1946), making infected fruit readily identifiable for removal from arils production. There is no reported evidence that this fungus is associated with internal parts of the fruit, including arils. Packing house processes will remove the rind with the pathogen associated with it.	Assessment not required	Assessment not required	No

Pest	Present in India	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudocercospora punicae (Henn.) Deighton [Mycosphaerellales: Mycosphaerellaceae] (synonym: *Cercospora punicae* Henn.) Cercospora fruit spot	Yes (Chandra, Jadhav & Sharma 2010; Rangaswami & Mahadevan 1998)	Not known to occur	No: Pomegranate arils do not provide a pathway for *Pseudocercospora punicae*. This species is associated with pomegranate fruit (Phengsintham et al. 2011; USDA 2010). *Pseudocercospora punicae* produces symptoms, confined to the rind. There is no reported evidence that *P. punicae* is associated with internal parts of the fruit, including arils. Packing house processes will remove the rind with the pathogen associated with it.	Assessment not required	Assessment not required	No

Appendix B: Issues raised in stakeholder comments

This section outlines key technical issues raised by stakeholders during consultation on the draft report, and the department responses. Additional information on other issues raised by stakeholders, which are outside the scope of this technical report, is available on the department website.

Issue 1: Effectiveness of the '600 unit' on-arrival inspection procedure

Prior to release from biosecurity control in Australia, the department will verify that each consignment meets Australia's import conditions. Consignments are inspected to ensure they are free from visually-detectable quarantine pests, regulated articles or contaminants such as soil, animal and plant debris (biosecurity risk material). In conducting a phytosanitary inspection, the department samples and inspects goods in a manner that is consistent with the international standards ISPM 23: *Guidelines for phytosanitary inspection* and ISPM 31: *Methodologies for sampling consignments*.

Australia requires a high level of assurance that biosecurity risk material is not present in any consignment. For all imported horticultural produce (fresh, unprocessed fruit and vegetables) this assurance equates to a statistically-determined 95% level of confidence that infestation levels of 0.5% or more will be detected. This is achieved by a 600 unit inspection. For fresh pomegranate whole fruit, a single fruit is considered to be one unit of inspection, and for processed arils, a pack of arils is considered to be one unit of inspection. The department ensures that inspection methods used are capable of detecting target pests, and that inspectors are trained to implement these methods.

Stakeholders questioned whether the sampling and inspection regime should be varied across consignments of different sizes in order to retain the required level of assurance. As detailed in Table 1 of ISPM 31, a 600-unit sample achieves the required level of assurance for consignments of all sizes, and provides heightened levels of assurance when used in conjunction with small consignments.

Issue 2: Clarification of the requirements for export quality fruit proceeding to processing/packing

The department has reviewed the standard commercial production practices for the commodities, in particular the processes for receiving and quality checking fruit for further processing, and the standard operating requirements associated with this.

As outlined in Section 3.6.1: 'Packing house processes: whole fruit', and Section 3.6.2: 'Packing house processes: arils', the receival and quality check steps require that all fruit are checked by a quality assurance team for damage, and for any signs of pests or diseases. Only commercial export quality fruit proceed for processing, which means that any fruit that are damaged or diseased are removed from the processing line and discarded.

Issue 3: Review of the risk assessments for *Deudorix epijarbas*, *Deudorix isocrates*, *Aphis punicae*, *Cenopalpus pulcher, Tenuipalpus granati, Tenuipalpus punicae*, *Drosicha dalbergiae, Coleophoma empteri* and *Elsinoë punicae*

The department reviewed the draft risk assessments for *Deudorix epijarbas* (cornelian butterfly)*, Deudorix isocrates* (pomegranate butterfly), *Aphis punicae* (pomegranate aphid), *Cenopalpus pulcher* (flat scarlet mite), *Tenuipalpus granati* (pomegranate mite), *Tenuipalpus punicae* (false spider mite), *Drosicha dalbergiae* (almond mealybug)*, Coleophoma empetri* (ripe rot) and *Elsinoë punicae* (pomegraanaate scab). After consideration of stakeholder comments, and further analyses of the literature and rationales presented in the draft risk assessments, the department revised some ratings. Changes to the risk ratings and the justifications for these changes are outlined below.

Deudorix epijarbas (cornelian butterfly) and *Deudorix Isocrates* (pomegranate butterfly)

The department reviewed the risk assessment for *D. epijarbas* and *D. isocrates* for processed arils pathway and considers that the risk assessment ratings for the likelihood of distribution be revised.

The risk assessment for the likelihood of distribution took into account the modified atmosphere packaging filled with nitrogen and carbon-dioxide, creating a decreased oxygen environment, and lower storage and transport temperature at below 5°C compared to pomegranate whole fruit. These factors are likely to reduce the survival of these two pests, and support the re-assessment of the likelihood rating for distribution from 'Low' to 'Very Low'. This re-assessment has not resulted in a change to the unrestricted risk estimate of 'Negligible'; therefore, specific pest management measures are still not required.

Aphis punicae (pomegranate aphid)

The department reviewed the draft assessment of direct consequences for plant life or health. The review resulted in a change to the consequence assessment as *A. punicae* is reported as an economically important pest of pomegranate, causing considerable yield loss. In addition, the sticky honeydew the pest produces on leaves and fruit can lead to secondary infection by other pests.

This change resulted in a change to the qualitative impact score, and therefore the overall consequence rating was revised from 'Very Low' to 'Low'. The unrestricted risk estimate for *A. punicae* is now re-assessed from 'Negligible' to 'Very Low', which achieves the ALOP for Australia. Therefore, specific risk management measures are not required for *A. punicae.*

Cenopalpus pulcher (flat scarlet mite)

The department further assessed *Cenopalpus pulcher*, especially with respect to its status in India and association with pomegranate fruit, and concluded that the evidence does not support an association of the pest with the pathway. Most literature on the status of this pest in India and its association with the pathway cite Balikai, Kotikal and Prasanna (2009), who quoted a publication from 1975 (Nair 1975) which reported *C. pulcher* on pomegranate in India. However, there is no recent primary evidence or other reports to support the presence of this pest on the pathway. Therefore, the pest has been removed from further assessment; the rationale for this action is further described in Appendix A-1.

Tenuipalpus granati (pomegranate mite) and *Tenuipalpus punicae* (false spider mite)

The department has reviewed the draft risk assessment for *T. granati* and *T. punicae* and considers the risk assessment ratings for the likelihoods of importation should be revised.

While *T. granati* and *T. punicae* are present in India, these mite species are external pests of pomegranate, and packing house processes are likely to minimise their presence on the fruit. These factors support the re-assessment of the likelihood of importation from 'High' to 'Low'.

Drosicha dalbergiae (almond mealybug)

The department further reviewed the consequence assessment for *Drosicha dalbergiae*, due to its reported association with some of the key horticulture crops in Australia, including apple, almond and citrus. These commodities are grown throughout many jurisdictions in Australia.

The department notes that these horticulture industries already manage scale insect pests in Australian orchards and existing control measures may limit the potential impact of this pest. Therefore, the overall rating is considered appropriate for the potential consequences of *D. dalbergiae* if it were to establish in Australia. Relevant text is included under Section 4.4.5, 'Consequences' to further support this rating.

Coleophoma empetri (ripe rot)

The department reviewed the draft risk assessment for *Coleophoma empetri* and revised the risk assessment ratings for the likelihoods of importation, distribution and establishment.

The re-assessment of likelihood of importation has more specifically taken into account the key attributes of the pest, primarily its limited association with pomegranate fruit in India. A relative lack of reporting about this fungus, particularly on pomegranate when compared to other pomegranate pests, is taken as indicating that pomegranate is not a major host, and that as a result, pest prevalence is likely to be low in pomegranate orchards. These factors support the re-assessment of the likelihood of importation from 'Low' to 'Very Low'.

The re-assessment of likelihood of distribution has taken into account considerations that although *C. empetri* may survive in pomegranate waste discarded in the environment, production of spores is likely to be limited by dry conditions in many parts of Australia. On this basis the likelihood of distribution is re-assessed from 'Moderate' to 'Low'.

The department also reviewed the draft risk assessment of the likelihood of establishment of *C. empetri.* A further assessment of literature and of the factors pertinent to the likelihood of establishment, in particular the wide range of potential hosts including many species of *Eucalyptus* which are widespread across Australia, combined with the pathogen's ability to survive in diverse environmental conditions, supported re-assessment of the likelihood of establishment from 'Moderate' to 'High'.

The revised ratings for importation, distribution and establishment have not resulted in a change to the unrestricted risk estimate of 'Negligible'. Therefore, specific risk management measures are not required for this pest.

Elsinoë punicae (pomegranate scab)

The department reviewed the draft risk assessment for *Elsinoë punicae* and considers the risk assessment rating for the likelihood of importation should be revised.

The re-assessment of the likelihood of importation has taken into account the key attributes of the pest, including its level of association with pomegranate, and reported disease incidence across India. Review of literature and other factors, such as the potential for lightly infected fruit with no visible symptoms to go undetected during harvest and packing, supports a re-assessment of the likelihood of importation from 'Very Low' to 'Low'.

Similarly, the department reviewed the draft assessment of the likelihood of spread of *E. punicae.* Further analysis of the literature and factors considered in the draft assessment, such as the limited availability of suitable host material, the specific weather conditions required for sporulation and dispersal of spores, and the natural barriers in Australia such as arid areas, climatic differences and long distances between pomegranate orchards, and interstate quarantine regulations collectively supported a re-assessment of the likelihood of spread from 'Moderate' to 'Low'.

The revised ratings for the likelihoods of importation and spread have not resulted in a change to the draft unrestricted risk estimate of 'Negligible'. Therefore, specific risk management measures are not required for this pest.

Issue 4: Potential for economic consequences of a number of pests in Appendix A-1.

The department reviewed the pest categorisation of a number of pests that were identified in Appendix A-1 as not having potential for economic consequences, and which therefore had not been assessed further.

As a consequence of the review of the pest categorisation, a further eight pests are categorised as present in Australia, three other pests are categorised as unlikely to be associated with commercially-produced export quality pomegranate fruit, and one pest is categorised as not having potential to establish and spread in Australia. Therefore, these pests do not require further categorisation in relation to potential for economic consequences or further risk assessment. Further information and references have been provided where appropriate to support the outcomes of the review.

Issue 5: Review of evidence for the presence of certain pests in India and pathway association

The department reviewed the evidence for the presence of certain pests in India and/or their association with pomegranate fruit in India. Further examination of the literature supports the original assessments and pest associations with pomegranate fruit, and in these cases the originally assessed risk ratings have been retained.

The department also further reviewed the geographic distribution of *Bactrocera carambolae* (Carambola fruit fly). Although *B. carambolae* is reported to be present only in the islands of Andaman and Nicobar, but not on mainland India, *B. carambolae* was assessed further (Section 4.1) because there are no biosecurity controls to prevent the introduction of *B. carambolae* from those islands to mainland India and its pomegranate production areas.

The review has not resulted in a change to the assessment, and further information and references to support the pest presence in India and pathway association have been included in the report.

Issue 6: Review of the risk assessment for *Xanthomonas axonopodis* pv. *punicae*

The draft report assessed the combined likelihood of entry (importation x distribution), establishment and spread as ‘Low’, consequences as ‘Moderate’ and the unrestricted risk as ‘Low’. The department reviewed the draft risk assessment for *Xanthomonas axonopodis* pv. *punicae* and considers the proposed risk ratings are appropriate. As detailed in Chapter 4 (Section 4.10), factors that limit the likelihood of entry, establishment and spread include:

1. notable symptoms of established infections, and subsequent likelihood of exclusion of fruit during processing
2. limited ability of the pathogen to disperse from infected pomegranate waste
3. unfavourable climatic conditions.

Issue 7: Potential association of *Xylella fastidiosa* with pomegranate fruit

Consistent with the pest risk analysis principles outlined in ISPM 11 (FAO 2019c), Appendices A-1 and A-2 cover pests that are likely be on the pathways under consideration, namely, whole pomegranate fruit and processed arils produced for export using standard commercial production and packing procedures in India. Appendices A-1 and A-2 do not present a comprehensive list of all the pests associated with the entire pomegranate plant.

The department recognises *Xylella fastidiosa* as a pest of significant biosecurity concern because of its environmental and economic impacts, and the many commercial and ornamental plant species that can be infected and/or killed by this bacterial pathogen (DAWE 2020). The complex biology of this bacterium enables it to colonise numerous host plants and facilitates its spread to new areas (DAWR 2017). Over 350 cultivated and uncultivated herbaceous and woody plant species are now known to be hosts of *X. fastidiosa* (IPPC 2017a), and the host range of *X. fastidiosa* is anticipated to increase as different bacterial subspecies continue to invade new territories.

Xylella fastidiosa spreads in the water-conducting system (the xylem) of susceptible plants and is transmitted primarily by movement of infected nursery stock, and by insect vectors that feed on xylem sap of infected plants and then spread the pest to other plants (Almeida & Nunney 2015). Hence, the movement of plant propagative material is considered a high-risk import pathway. For this reason, the approach Australia has taken in emergency measures against the entry of *X. fastidiosa* is to regulate all nursery stock material in the families of plants that are known to contain *X. fastidiosa* hosts. Pomegranate belongs to the plant family Lythraceae, which does contain *X. fastidiosa* hosts (e.g. crepe myrtle).

Although *X. fastidiosa* infects plants systemically and, in theory, there is therefore a possibility of this bacterium being present in fruit, there is no published literature that directly confirms that pomegranate is a host of *X. fastidiosa*, or that pomegranate fruit provides a pathway for *X. fastidiosa*. For these reasons, *X. fastidiosa* was not included in the pest categorisation tables (Appendices A-1 and A-2) of this report.

If *X. fastidiosa* was confirmed to be associated with pomegranate fruit, the import of pomegranate fruit would be considered very unlikely to be a viable pathway for the establishment and spread of the pathogen in Australia.

There are two theoretical ways that fruit could provide a pathway, namely by:

1. vector acquisition of the bacterium from infected fruit or fruit waste, and

2. seed transmission from infected arils that have been discarded.

Vector acquisition

For vector acquisition to occur, the bacterium would need to persist in vascular tissue of the fruit or fruit waste until a potential vector in Australia fed on the material and acquired the bacterium.

The cold storage and transport of pomegranate fruit is likely to reduce the survival and development of *X. fastidiosa*. Research has shown that levels of *X. fastidiosa* in infected grape clusters declined sharply during cold storage (Purcell and Saunders (1995). The bacterium was recovered in about 20% of the samples of host fruit one day after harvest, and not recovered after 21 days of cold storage. Another study found that *X. fastidiosa* in grapevines could not multiply at 12°C, and that the bacterial population declined by 230-fold when kept at 5°C for two weeks (Feil & Purcell 2001). Varela (2000) reported that a consistent requirement for *X. fastidiosa* to cause Pierce's disease in vineyards is a mild winter, and linked the rare occurrence and low severity of the disease in parts of USA with colder winters to the poor ability of the bacterium to survive those winter temperatures. The negative effect of cold temperature on *X. fastidiosa* was also demonstrated in American sycamore hosts (Henneberger et al. 2004). Therefore, it is expected that if any fruit were to contain *X. fastidiosa,* the number of bacteria would substantially decline during cold storage. *X. fastidiosa* is known to be even more sensitive to temperatures below freezing (Henneberger et al. 2004; Meyer & Kirkpatrick 2008; Purcell 1980).

Vectors known to transmit *X. fastidiosa*, such as glassy-winged sharpshooter (*Homalodisca vitripennis*) and blue-green sharpshooter (*Graphocephala atropunctata*), are not known to be present in Australia. Most reported insect vectors of *X. fastidiosa* are members of the vascular-feeding hemipteran families Cicadellidae (sharpshooters) and Cercopidae (spittlebugs) (Almeida & Nunney 2015), which require succulent or actively growing plant tissue as food sources (Varela 2000).

Xylem-feeding insect vectors generally feed on stems and leaf veins rather than fruit, and Australian xylem-feeding insects are not known to be associated with fruit (CSIRO 1991). Purcell and Saunders (1995) demonstrated that for a known *X. fastidiosa* host (grapevine), fruit clusters are not attractive as compared to foliage for a key insect vector (blue-green sharpshooter). The authors found that exposure of the vector to a diseased cluster did not result in transmission of the bacterium, even when conditions for acquisition were made more favourable by exposing more rachis by removal of some fruits. In contrast, under the same conditions and using the same vectors, but with diseased grape foliage as acquisition sources, high rates of transmission were observed. These studies thus found no evidence for acquisition or transmission of the bacterium from grape clusters. The authors also suggested that the attractiveness of fruit that are harvested and stored was likely to be even lower than fresh fruit. More broadly, Huberty and Denno (2004) demonstrated that vascular-feeding arthropods display negative responses when forced to feed on living water-stressed hosts. Pomegranate fruit and fruit waste which have been severed from the transpiration stream will continue to lose moisture and vascular turgor, and are likely to become even less attractive to any potential vector.

This information supports an assessment that the number of viable bacteria in fruit and fruit waste is likely to be low, and that it is even more unlikely that any potential vector would be attracted to feed on fruit waste. On this basis, vector transmission of *X. fastidiosa* from discarded fruit and waste is considered to be highly unlikely.

Seed transmission

Xylella fastidiosa is not known to be spread by seeds. There is a single report of *X. fastidiosa* being seedborne in citrus (Li et al. 2003), causing citrus variegated chlorosis. However, a seven-year study evaluating the possibility of seed-to-seedling transmission of *X. fastidiosa* in sweet oranges found no evidence that the bacterium was transmitted from seeds to seedlings (Coletta-Filho et al. 2014). Hartung et al. (2014) also investigated seed-to-seedling transmission in sweet orange from Brazil using seed extracted from fruit heavily infected by and symptomatic for *X. fastidiosa*, as well as seed from asymptomatic fruit from the same trees. Those authors also found no evidence for the vertical transmission of the bacterium through contaminated seed. A further seed transmission study, also carried out in Brazil on sweet oranges and lemons, came to the same conclusion (Cordeiro et al. 2014).

In summary, the likelihood of *X. fastidiosa* successfully establishing in Australia via the commercial pomegranate fruit pathway is considered to be negligible.

Issue 8: Food safety

Stakeholders made comments about food safety matters, especially with respect to 'ready-to-eat' arils. It is emphasised that the purpose of this risk analysis is to assess the biosecurity risks potentially associated with the importation of whole pomegranate fruit and processed arils.

While food safety assessment is not within the scope of this analysis, some information regarding food safety requirements is included in Chapter 5 of the report ('Meeting Australian food laws'). All food imported for human consumption must comply with the requirements of the *Imported Food Control Act 1992*, as well as Australian state and territory food laws. These laws require all imported foods to meet the standards set out in the Australia New Zealand Food Standards Code (the Code).

Other issues

The department has made a number of other changes to the risk analysis following consideration of stakeholder comments on the draft report and subsequent review of scientific literature. These include:

- minor amendments to Chapter 3: 'India's commercial production practices for pomegranate whole fruit and processed arils', to clarify the production and processing steps for commercially produced pomegranate whole fruit and processed arils
- amendments to Chapter 4: 'Pest risk assessment', to further clarify the assessments of a number of pests
- minor corrections, rewording and editorial changes for consistency, accuracy, clarity and web-accessibility.

Glossary

Term or abbreviation	Definition
Additional declaration	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information on a consignment in relation to regulated pests (FAO 2019b).
Appropriate level of protection (ALOP)	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995b).
Appropriate level of protection (ALOP) for Australia	The *Biosecurity Act 2015* defines the appropriate level of protection (or ALOP) for Australia as a high level of sanitary and phytosanitary protection aimed at reducing biosecurity risks to very low, but not to zero.
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2019b).
Area of low pest prevalence	An area, whether all of a country, part of a country, or all parts of several countries, as identified by the competent authorities, in which a specific pest occurs at low levels and which is subject to effective surveillance, control or eradication measures (FAO 2019b).
Arils	A fleshy and usually brightly coloured and edible covering that surrounds the seed.
Arthropod	The largest phylum of animals, including the insects, arachnids and crustaceans.
Asexual reproduction	The development of new individual from a single cell or group of cells in the absence of meiosis.
Australian territory	Australian territory as referenced in the *Biosecurity Act 2015* refers to Australia, Christmas Island and Cocos (Keeling) Islands.
Biosecurity	The prevention of the entry, establishment or spread of unwanted pests and infectious disease agents to protect human, animal or plant health or life, and the environment.
Biosecurity measures	The *Biosecurity Act 2015* defines biosecurity measures as measures to manage any of the following: biosecurity risk, the risk of contagion of a listed human disease, the risk of listed human diseases entering, emerging, establishing themselves or spreading in Australian territory, and biosecurity emergencies and human biosecurity emergencies.
Biosecurity import risk analysis (BIRA)	The *Biosecurity Act 2015* defines a BIRA as an evaluation of the level of biosecurity risk associated with particular goods, or a particular class of goods, that may be imported, or proposed to be imported, into Australian territory, including, if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or the class of goods, to a level that achieves the ALOP for Australia. The risk analysis process is regulated under legislation.
Biosecurity risk	The *Biosecurity Act 2015* refers to biosecurity risk as the likelihood of a disease or pest entering, establishing or spreading in Australian territory, and the potential for the disease or pest causing harm to human, animal or plant health, the environment, economic or community activities.
Calyx	A collective term referring to all of the sepals in a flower.
Consignment	A quantity of plants, plant products or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) (FAO 2019b).
Contaminating pest	A pest that is carried by a commodity, packaging, conveyance or container, or present in a storage place and that, in the case of plants and plant products, does not infest them (FAO 2019b).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2019b).

Term or abbreviation	Definition
Crawler	Intermediate mobile nymph stage of certain Arthropods.
Diapause	Period of suspended development/growth occurring in some insects, in which metabolism is decreased.
The department	The Department of Agriculture, Water and the Environment
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 2019b).
Endemic	Belonging to, native to, or prevalent in a particular geography, area or environment.
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO 2019b).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2019b).
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2019b).
Fumigation	A method of pest control that completely fills an area with gaseous pesticides to suffocate or poison the pests within.
Genus	A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.
Goods	The *Biosecurity Act 2015* defines goods as an animal, a plant (whether moveable or not), a sample or specimen of a disease agent, a pest, mail or any other article, substance or thing (including, but not limited to, any kind of moveable property).
Host	An organism that harbours a parasite, mutual partner, or commensal partner, typically providing nourishment and shelter.
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2019b).
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2019b).
Infection	The internal 'endophytic' colonisation of a plant, or plant organ, and is generally associated with the development of disease symptoms as the integrity of cells and/or biological processes are disrupted.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2019b).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (FAO 2019b).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced or used (FAO 2019b).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2019b).
International Plant Protection Convention (IPPC)	The IPPC is an international plant health agreement, established in 1952, that aims to protect cultivated and wild plants by preventing the introduction and spread of pests. The IPPC provides an international framework for plant protection that includes developing International Standards for Phytosanitary Measures (ISPMs) for safeguarding plant resources.
International Standard for Phytosanitary Measures (ISPM)	An international standard adopted by the Conference of the Food and Agriculture Organization, the Interim Commission on Phytosanitary Measures or the Commission on Phytosanitary Measures, established under the IPPC (FAO 2019b).
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO 2019b).

Term or abbreviation	Definition
Larva	A juvenile form of animal with indirect development, undergoing metamorphosis (for example, insects or amphibians).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin et cetera, forming part of a consignment (FAO 2019b). Within this report a 'lot' refers to a quantity of fruit of a single variety, harvested from a single production site during a single pick and packed at one time.
Mature fruit	Commercial maturity is the start of the ripening process. The ripening process will then continue and provide a product that is consumer-acceptable. Maturity assessments include colour, starch, index, soluble solids content, flesh firmness, acidity, and ethylene production rate.
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2019b).
Non-regulated risk analysis	Refers to the process for conducting a risk analysis that is not regulated under legislation (Biosecurity import risk analysis guidelines 2016).
Nymph	The immature form of some insect species that undergoes incomplete metamorphosis. It is not to be confused with larva, as its overall form is already that of the adult.
Official control	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2019b).
Orchard	A contiguous area of commodity trees operated as a single entity. Within this report a single orchard is covered under one registration and is issued a unique identifying number.
Pathogen	A biological agent that can cause disease to its host.
Pathway	Any means that allows the entry or spread of a pest (FAO 2019b).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2019b).
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 2019b).
Pest free area (PFA)	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2019b).
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 2019b).
Pest free production site	A defined portion of a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period and that is managed as a separate unit in the same way as a pest free place of production (FAO 2019b).
Pest risk analysis (PRA)	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it (FAO 2019b).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences (FAO 2019b).
Pest risk assessment (for regulated non-quarantine pests)	Evaluation of the probability that a pest in plants for planting affects the intended use of those plants with an economically unacceptable impact (FAO 2019b).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2019b).

Term or abbreviation	Definition
Pest risk management (for regulated non-quarantine pests)	Evaluation and selection of options to reduce the risk that a pest in plants for planting causes an economically unacceptable impact on the intended use of those plants (FAO 2019b).
Pest status (in an area)	Presence or absence, at the present time, of a pest in an area, including where appropriate its distribution, as officially determined using expert judgement on the basis of current and historical pest records and other information (FAO 2019b).
Phytosanitary certificate	An official paper document or its official electronic equivalent, consistent with the model of certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (FAO 2019b).
Phytosanitary certification	Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (FAO 2019b).
Phytosanitary measure	Phytosanitary relates to the health of plants. Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2019b). In this risk analysis the term 'phytosanitary measure' and 'risk management measure' may be used interchangeably.
Phytosanitary procedure	Any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance or treatments in connection with regulated pests (FAO 2019b).
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 2019b).
Polyphagous	Feeding on a relatively large number of hosts from different plant family and/or genera.
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2019b).
Practically free	Of a consignment, field or place of production, without pests (or a specific pests) in numbers or quantities in excess of those that can be expected to result from, and be consistent with good cultural and handling practices employed in the production and marketing of the commodity (FAO 2019b).
Production site	In this report, a production site is a continuous planting of commodity trees treated as a single unit for pest management purposes. If an orchard/vineyard is subdivided into one or more units for pest management purposes, then each unit is a production site. If the orchard/vineyard is not subdivided, then the orchard is also the production site.
Pupa	An inactive life stage that only occurs in insects that undergo complete metamorphosis, for example butterflies and moths (Lepidoptera), beetles (Coleoptera) and bees, wasps and ants (Hymenoptera).
Quarantine	Official confinement of regulated articles for observation and research or for further inspection, testing or treatment (FAO 2019b).
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 2019b).
Regulated article	Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2019b).
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO 2019b).
Regulated pest	A quarantine pest or a regulated non-quarantine pest (FAO 2019b).
Restricted risk	Restricted risk is the risk estimate when risk management measures are applied.

Term or abbreviation	Definition
Risk analysis	Refers to the technical or scientific process for assessing the level of biosecurity risk associated with the goods, or the class of goods, and if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or class of goods to a level that achieves the ALOP for Australia.
Risk management measure	Are conditions that must be met to manage the level of biosecurity risk associated with the goods or the class of goods, to a level that achieves the ALOP for Australia. In this risk analysis, the term 'risk management measure' and 'phytosanitary measure' may be used interchangeably.
Saprophyte	An organism deriving its nourishment from dead organic matter.
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO 2019b).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures.
Stakeholders	Government agencies, individuals, community or industry groups or organizations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues.
Surveillance	An official process which collects and records data on pest occurrence or absence by surveying, monitoring or other procedures (FAO 2019b).
Systems approach(es)	The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection against regulated pests.
Trash	Soil, splinters, twigs, leaves and other plant material, other than fruit as defined in the scope of this risk analysis. For example, stem and leaf material, seeds, soil, animal matter/parts or other extraneous material
Treatment	Official procedure for the killing, inactivation or removal of pests, or for rendering pests infertile or for devitalisation (FAO 2019b).
Turgor	The normal distention or rigidity of plant cells, resulting from the pressure exerted by the cell contents on the cell walls.
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk management measures.
Vector	An organism that does not cause disease itself, but which causes infection by conveying pathogens from one host to another.
Viable	Alive, able to germinate or capable of growth.

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