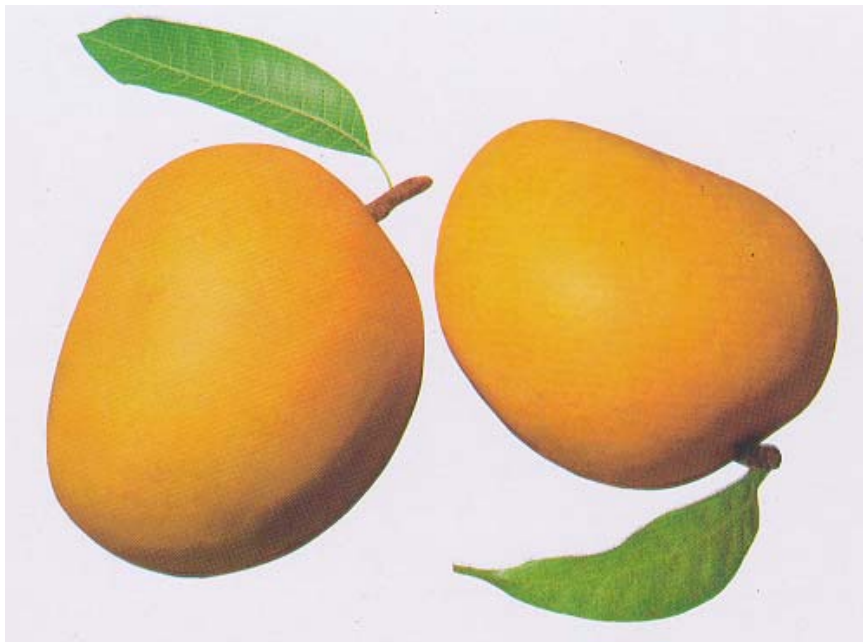




Australian Government

Biosecurity Australia

**Draft Extension of Policy for the
Importation of Fresh Mangoes
(*Mangifera indica* L.) from Taiwan**



December 2005

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TABLE OF CONTENTS

GLOSSARY OF TERMS AND ABBREVIATIONS	7
EXECUTIVE SUMMARY.....	11
INTRODUCTION.....	13
PROPOSAL TO IMPORT MANGOES FROM TAIWAN	14
Background.....	14
Mangoes from Taiwan.....	14
Scope of extension of policy	14
Australia's current quarantine policy for fresh mango fruit.....	15
International policy.....	15
The Philippines (Guimaras Island)	15
THE FRESH MANGO INDUSTRY	17
The mango industry in Australia	17
Production.....	17
Export of mangoes from Australia.....	18
Mango industry in Taiwan	18
Cultivars	18
Production.....	19
Export of mangoes from Taiwan	20
METHOD FOR PEST RISK ANALYSIS	21
Stage 1: Initiation	21
Stage 2: Pest Risk Assessment	21
Pest categorisation	21
Assessment of the probability of entry, establishment or spread.....	22
Assessment of consequences	23
Method for determining the unrestricted risk estimate	25
Australia's appropriate level of protection (ALOP)	26
Stage 3: Pest Risk Management	26
PEST RISK ANALYSIS	28
Stage 1: Initiation	28
Stage 2: Pest Risk Assessment	28
Pest categorisation	28
Risk assessments for quarantine pests	29
Arthropod Pests	30

Fruit flies	30
Armoured scales	34
Soft scales	37
Mealybugs.....	41
Mango Aphid	45
Cocoa tussock moth	48
Mango Thrips.....	51
Pathogen	54
Mango scab	54
Risk assessment conclusion.....	59
Stage 3: Pest Risk Management	59
Risk management measures and operational systems.....	60
[1] Pre-export disinfection for the management of fruit fly species.....	60
[2] Inspection and remedial action for mealybugs	62
[3] Operational systems for the maintenance and verification of phytosanitary status	63
[4] Action for non-complying lots	68
[5] Uncategorized pests	68
DRAFT IMPORT CONDITIONS.....	69
1 Registration of export orchards.....	69
2 Registration of packhouses and auditing of procedures.....	70
3 Pre-export vapour heat treatment (VHT).....	70
4 Packing and labelling.....	72
5 Storage and movement	72
6 Targeted pre-export inspection and remedial action by BAPHIQ	73
7 Phytosanitary certification by BAPHIQ	74
Additional declaration	74
Distinguishing marks	74
Treatments	74
8 Targeted on-arrival quarantine inspection and remedial action, and clearance by AQIS.....	75
Remedial action for non-complying lots.....	75
Documentation errors	76
9 Uncategorized pests.....	76
10 Audit of protocol	76
11 Review of policy	76
CONCLUSIONS.....	77
REFERENCES.....	78
APPENDIX 1: PEST CATEGORISATION FOR MANGOES FROM TAIWAN	84

APPENDIX 2: POTENTIAL FOR ESTABLISHMENT OR SPREAD AND CONSEQUENCES.....	125
APPENDIX 3: DATA SHEETS FOR QUARANTINE PESTS.....	138
Fruit flies	138
Armoured scales	144
Soft scales	151
Mealybugs	157
Mango aphid	165
Cocoa tussock moth.....	167
Mango thrips.....	170
Mango scab	173

GLOSSARY OF TERMS AND ABBREVIATIONS

Additional declaration.....	a statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information pertinent to the phytosanitary condition of a consignment
ALOP.....	appropriate level of protection
AQIS.....	Australian Quarantine and Inspection Service
Area.....	an officially defined country, part of a country or all or parts of several countries
BAPHIQ.....	Taiwan Bureau of Animal Plant Health Inspection and Quarantine
BCIQ.....	Taiwan Bureau of Commodity Inspection and Quarantine (now BAPHIQ)
Biosecurity Australia.....	a prescribed agency within the Australian Government Department of Agriculture, Fisheries and Forestry. Biosecurity Australia provides science based quarantine assessments and policy advice that protects Australia's favourable pest and disease status and enhances Australia's access to international animal and plant related markets
BPI.....	Philippines Bureau of Plant Industry
Consignment.....	a quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots)
Control (of a pest).....	suppression, containment or eradication of a pest population
DAFF.....	Australian Government Department of Agriculture, Fisheries and Forestry
Endangered area.....	an area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss
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

Establishment.....	the perpetuation, for the foreseeable future, of a pest within an area after entry
Establishment potential.....	likelihood of the establishment of a pest
FAO.....	Food and Agriculture Organization of the United Nations
Fresh.....	living; not dried, deep-frozen or otherwise conserved
Fruits and vegetables.....	a commodity class for fresh parts of plants intended for consumption or processing and not for planting
Host.....	species of plants capable, under natural conditions, of suiting a specific pest
ICON.....	AQIS Import Conditions database
Import Permit.....	official document authorising importation of a commodity in accordance with specified phytosanitary requirements
Infestation (of a commodity).....	presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection
Inspection.....	official visual inspection of plants, plant products or other regulated articles to determine if pests are present and/or to determine compliance with phytosanitary regulations
Intended use.....	declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used
Interception (of a pest).....	the detection of a pest during inspection or testing of an imported consignment
Introduction.....	entry of a pest resulting in its establishment
IPPC.....	International Plant Protection Convention, as deposited with FAO in Rome in 1951 and subsequently amended
IRA.....	Import Risk Analysis, an administrative process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication
ISPM.....	International Standard on Phytosanitary Measures
Lot.....	a number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., and forming part of a consignment
National Plant Protection Organisation.....	official service established by a government to discharge the functions specified by the IPPC (DAFF is Australia's NPPO)
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
Pathway.....	any means that allows the entry or spread of a pest
Pest.....	any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products
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
Pest free area.....	an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained
Pest risk analysis.....	the process of evaluating biological or other scientific evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it
Pest risk analysis area.....	area in relation to which a pest risk analysis is conducted
Pest risk assessment (for quarantine pests).....	evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences
Pest risk management (for quarantine pests).....	evaluation and selection of options to reduce the risk of introduction and spread of a pest
Phytosanitary certificate.....	Certificate patterned after the model certificates of the IPPC
Phytosanitary measure.....	any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests
Phytosanitary regulation.....	official rule to prevent the introduction and/or spread of quarantine pests, by regulating the production, movement or existence of commodities or other articles, or the normal activity of persons, and by establishing schemes for phytosanitary certification
Polyphagous.....	feeding on a relatively large number of host plants from different plant families
Quarantine pest.....	a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled

Regulated article.....	any plant, plant product, storage place, packing, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved
Restricted risk.....	‘Restricted’ risk estimates are those derived when risk management measures are used
Spread.....	expansion of the geographical distribution of a pest within an area
SPS Agreement.....	WTO Agreement on the Application of Sanitary and Phytosanitary Measures
Stakeholders.....	Government agencies, individuals, community or industry groups or organisations, whether in Australia or overseas, including the proponent/applicant for a specific proposal
Unrestricted risk.....	‘Unrestricted’ risk estimates are those derived in the absence of risk management measures
VHT.....	vapour heat treatment
WTO.....	World Trade Organization

EXECUTIVE SUMMARY

This draft extension of policy report proposes that fresh mangoes from Taiwan be allowed entry into Australia subject to the imposition of phytosanitary measures for four fruit flies and four mealybugs. These pests require the use of risk management measures in addition to Taiwan's standard commercial production practices to reduce the quarantine risk to a very low level to meet Australia's appropriate level of protection (ALOP).

A combination of risk management measures and operational systems aim to provide a high level of sanitary and phytosanitary protection that will reduce risk associated with the importation of mangoes from Taiwan to meet Australia's appropriate ALOP specifically:

- pre-export vapour heat treatment (VHT) for the management of fruit flies;
- inspection and remedial action for mealybugs;
- operational systems for the maintenance and verification of the phytosanitary status of mangoes from Taiwan including;
 - registration of export orchards;
 - registration of packing houses and auditing of procedures;
 - packaging and labelling requirements;
 - specific conditions for storage and movement;
 - phytosanitary certification by Taiwanese quarantine authorities; and
 - on-arrival quarantine clearance by Australian quarantine authorities.

Australia initiated a pest risk analysis for the importation of fresh mangoes from Taiwan in October 2005, following a request for market access from Taiwan's Bureau of Animal and Plant Health, Inspection and Quarantine (BAPHIQ) in June 2003.

Subject to a range of risk management measures and phytosanitary procedures, Australia currently permits the importation of mango (*Manifera indica* L.) from the Republic of the Philippines (the Philippines) (Guimaras Island), Mexico and Haiti.

A preliminary assessment by Biosecurity Australia of the pests potentially associated with mangoes from Taiwan indicated that the pests do not pose significantly different quarantine risks, or require significantly different management measures, than those for which policy exists. In view of this, Biosecurity Australia advised stakeholders on 28 October 2005 in Biosecurity Australia Policy Memorandum (BAPM) 2005/14 that the access request would be considered as an extension of existing import policy.

In the pest risk analysis for mangoes from Taiwan into Australia, Biosecurity Australia identified pests and diseases of mango from Taiwan potentially associated with the fresh mango fruit pathway and not present in Australia, or if in Australia, to be of limited distribution and under official control. These pests were further categorised for their

potential for establishment and spread within Australia, as well as potential for consequences. On this basis, 18 arthropods and one fungal pathogen were categorised as quarantine pests.

Detailed risk assessments were conducted for those pests that were categorised as quarantine pests, to determine an unrestricted risk estimate for each organism. For those pests for which the unrestricted risk estimate did not meet Australia's appropriate level of protection (ALOP), risk management measures were identified. This draft report presents details of proposed phytosanitary risk management measures, operational procedures and draft import conditions, together with their objectives.

Biosecurity Australia invites comments on the technical and economic feasibility of the proposed phytosanitary risk management measures. In particular, comments are sought on their appropriateness and any other measures that stakeholders consider would provide equivalent risk management.

INTRODUCTION

Biosecurity Australia is a prescribed agency within the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF). Biosecurity Australia is responsible for developing international quarantine policy for imports and for liaising with overseas National Plant Protection Organisations (NPPOs) to determine their requirements for exports of Australian plants and plant products.

In June 2003, the Taiwan Bureau of Animal and Plant Health, Inspection and Quarantine (BAPHIQ) requested market access for mangoes (*Mangifera indica* L.) into Australia. Quarantine policy currently exists for the importation into Australia of fresh mangoes from the Republic of the Philippines (the Philippines) (Guimaras Island), Mexico and Haiti. In addition, a draft revised import policy report for mangoes from India was released for stakeholder comment on 2 July 2004 (DAFF, 2004).

A preliminary assessment indicated that the pests associated with mangoes from Taiwan do not pose significantly different quarantine risks, or require significantly different management measures, than those for which policy already exists. Biosecurity Australia therefore determined that the market access request for mangoes from Taiwan could be progressed as an extension of existing import policy.

This extension of policy report is based on import policy for mango fruit from the Philippines, detailed in the import risk analysis (IRA) (AQIS, 1998; AQIS, 1999) and the draft revised policy for mangoes from India (DAFF, 2004).

As the initial step in the pest risk analysis (PRA) process, Biosecurity Australia identified and categorised pests associated with mangoes from Taiwan to identify the quarantine pests for Australia. Detailed risk assessments of these 18 arthropods and one fungal pathogen were conducted using the likelihood of entry, establishment or spread and associated consequences to determine an unrestricted risk estimate for each species.

Proposed phytosanitary risk management measures were then identified for each quarantine pest that did not meet the appropriate level of protection (ALOP) for Australia. These proposed risk management measures form part of the recommendations for the draft import conditions.

This report contains the following:

- background to this extension of policy and Australia's current quarantine policy for the importation of fresh mangoes;
- methodology and results of pest categorisation and risk assessment;
- proposed risk management measures; and
- draft import conditions.

PROPOSAL TO IMPORT MANGOES FROM TAIWAN

Background

Mangoes from Taiwan

In February and June 2003, BAPHIQ requested market access for mangoes into Australia. Biosecurity Australia requested a complete list of pests and diseases associated with the commodity, industry and production information, and proposed management options for quarantine pests. In June 2003, BAPHIQ provided a copy of the document '*Vapour Heat Treatment for Elimination of Dacus dorsalis and Dacus cucurbitae Infested in Mango Fruits Var. Haden*' (Kuo *et al.*, 1989) in support of a treatment for fruit flies. In July 2004, BAPHIQ provided a copy of the document '*Production and Cultivation of Litchi, Carambola and Mango in Taiwan*' (BAPHIQ, 2004) containing information on mango cultivars and production, and a list of pests and diseases of mangoes in Taiwan. In response to a request by Biosecurity Australia, BAPHIQ provided additional scientific literature references in August 2004.

Following a preliminary comparison of the pest lists, Biosecurity Australia determined that the quarantine risks of pests and diseases associated with mangoes from Taiwan were similar to those covered by existing policy. The Biosecurity Australia Policy Memorandum (BAPM) 2005/14 released on 28 October 2005 notified stakeholders that Biosecurity Australia was considering an import proposal for fresh mango fruit from Taiwan as an extension of existing import policy.

Scope of extension of policy

Biosecurity Australia has considered the quarantine risks associated with the importation of fresh mango fruit from Taiwan for the quarantine pests identified in the PRA section of this extension of policy, in accordance with *ISPM No. 11: Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms* (FAO, 2004).

The PRA forms the basis for development of import policy for the entry of fresh mango fruit that have been cultivated, harvested, packed and transported under standard, commercial and agronomic conditions from Taiwan into Australia.

The policy developed in this PRA for mangoes is applicable to any cultivar of mango from Taiwan.

Australia's current quarantine policy for fresh mango fruit

The Commonwealth Government is responsible for regulating the movement of plants and plant products into and out of Australia. However, State and Territory governments are primarily responsible for plant health controls within Australia. Legislation relating to resource management or plant health may be used by State and Territory government agencies to control interstate movement of plants and their products.

International policy

Australia currently has import policy for fresh mangoes from the Philippines (Guimaras Island), Mexico and Haiti.

Details of the importation requirements for fresh mango fruit from the Philippines, Mexico and Haiti are available on the AQIS Import Condition database (ICON) at <http://www.aqis.gov.au/icon>. All imported consignments of mangoes are subject to condition C6000 '*General import requirements for all fruits and vegetables*'. Condition C6000 requirements include an AQIS import permit, a quarantine entry, a Phytosanitary Certificate, use of appropriate packing materials, freedom from regulated articles, and on-arrival inspection and treatment by AQIS. In addition to general requirements, specific import conditions are mandated for each country.

The specific import conditions for the Philippines are relevant to this extension of existing policy and are summarised below.

The Philippines (Guimaras Island)

A Specific Commodity Understanding (SCU) with the Philippines for the importation of mangoes was signed in 1993 by representatives of AQIS and the Bureau of Plant Industry (BPI), the Philippines. The SCU was amended in 1999 (AQIS, 1999) and again in March 2000.

The SCU specifies that fresh mango fruit imported from the Philippines must be produced on Guimaras Island only. Guimaras Island is considered to be free of the quarantine pests mango seed weevil and mango pulp weevil based on surveys and monitoring.

State quarantine regulations currently prohibit the entry of Philippine mangoes into the state of Western Australia. This matter is under negotiation between Biosecurity Australia and the Department of Agriculture Western Australia.

The following ICON conditions apply:

Condition C6000 – General requirements for all fresh fruit and vegetables.

Condition C9212 – Conditions relating to the Specific Commodity Understanding between the AQIS and the BPI.

Conditions in the SCU also relate to specific quarantine pests, protocols for packing consignments of fruit and vapour heat treatment. AQIS requires all mango fruit from the Philippines to be vapour heat treated at not less than 46°C for at least 10 minutes for management of fruit flies.

THE FRESH MANGO INDUSTRY

The mango industry in Australia

Production

Mangoes are grown mainly in tropical and subtropical regions of Australia. The State of Queensland produced over 75% of Australia's total crop in 2003 (Cirillo, 2001; ABS, 2004). Most of the Queensland crop is produced around Bowen, Home Hill, Ayr and the Atherton Tableland (near Mareeba) (Kernot *et al.*, 1998). The Bowen region and the Atherton Tableland dominate the industry in planted area and current production (Kernot *et al.*, 1998).

Mangoes are also grown in the Northern Territory, which produced approximately 16% of the national crop in 2004 (ABS, 2004). Smaller production areas occur in Western Australia and along the northern coast of New South Wales (Cirillo, 2001; ABS, 2004).

The four main cultivars of mango grown in Australia are Kensington Pride (commonly known as Bowen Special), R2E2, Keitt and Palmer (Cirillo, 2001). Kensington Pride is the most important cultivar in Australia (Mukherjee, 1997), and accounts for almost 80% of production in Queensland (Kernot *et al.*, 1998). In addition, relatively small numbers of fruit are produced from other cultivars, such as Kent and Nam Doc Mai (Kernot *et al.*, 1998). These are grown in north Queensland, the Northern Territory and Western Australia. Two other cultivars (Brooks and Haden) are grown in Australia on a small scale. Haden makes up less than 2% of mango trees in Australia, and is mainly grown in the Kununurra district in Western Australia (Bally, 2004). About 50% of new plantings in Queensland in the mid 1990s consisted of newer cultivars such as Keitt, R2E2, Palmer and Nam Doc Mai (Holmes, 1997).

Because of the wide geographical distribution of growing regions, and the use of early and late-maturing cultivars, Australia is able to harvest mangoes for seven months of the year, from October to April (Kernot *et al.*, 1998; Cirillo, 2001). However, about 50% of Australian production occurs in December (Cirillo, 2001). Kensington Pride is harvested from October to January, the R2E2 cultivar is harvested from December to January, and Keitt and Palmer cultivars are harvested from January to late March (Cirillo, 2001).

Australian production is expected to increase as a result of current industry development and the significant plantings of mangoes over the last decade. Fluctuations in mango production occur between years because of irregular flowering (Australian Horticulture, 1995). Annual mango production in Australia averaged 38,627 tonnes between the 2000 and 2004 seasons (ABS, 2004). Australian mango production figures are presented in Table 1.

Table 1 Australia's mango production (tonnes) for 1999–2004

Season	NSW	NT	QLD	WA	TOTAL
1999–2000	–	5 244	30 770	1 922	37 936
2000–01	386	6 718	28 233	2 060	37 398
2001–02	259	6 071	32 361	2 281	40 973
2002–03	260	6 704	29 300	2 706	38 970
2003–04	433	6 027	28 516	2 192	37 168

Source: Australian Bureau of Statistics (2000, 2002, 2003, 2004)

Export of mangoes from Australia

Quantities of mangoes for export have steadily increased since 1999, from 2700 tonnes in 1999 to 3600 tonnes in 2001 (Collins *et al.*, 2004). The major export markets for Australian mangoes are Singapore and Hong Kong, each of which imported over 1000 tonnes in 2002–03 (Collins *et al.*, 2004). Mangoes are also exported to Japan, the United Arab Emirates, Saudi Arabia, Malaysia, France, Lebanon, Qatar, Oman, New Zealand and other smaller markets. Australia gained access for mangoes to the People's Republic of China in 2004; no exports have taken place to date.

Mango industry in Taiwan

Cultivars

Mangoes have been grown in Taiwan for over four hundred years (BAPHIQ, 2004). Commercial cultivation of mangoes in Taiwan centers on the production of six cultivars:

- (1) *Ts Xine* – Fruit of this cultivar possesses fruit with green peel, orange-yellow pulp and a large seed. Fruit are small and kidney-shaped, with an average weight of approximately 160 grams. The fruit is fibrous, but it has a good flavour and is suitable for eating or juicing (BAPHIQ, 2004).
- (2) *Irwin* – Fruit of this cultivar are elongate, egg-shaped, and have thin, red skin. They weigh on average 326 grams, and the pulp has few fibres (BAPHIQ, 2004).
- (3) *Jin Hwang* – These fruit are the largest of the six cultivars, and weigh an average of 1200 grams. They are elongate and oval in shape, and have a thin, flat seed which constitutes approximately 5% of the fruit's total weight. The skin and pulp are orange-yellow in colour (BAPHIQ, 2004).

(4) *Haden* – This cultivar originated in Florida, USA (Bally, 2004), and the fruit are egg-shaped, and weigh on average 325 grams. The skin is thick, and red on the outside and yellow on the inside (Bally, 2004). The pulp has few fibres, and ripens from June to July (BAPHIQ, 2004).

(5) *Keitt* – Fruit of this cultivar are medium-sized, weighing on average 679 grams. Fruit are egg-shaped, with thick pulp and either green or pale-red skin. It is fibrous only around the seed and ripens from August to October (BAPHIQ, 2004).

(6) *Tainoung No. 1* – The fruit of this cultivar is egg-shaped and pointed at one end. The average weight is 221 grams and the fruit has yellow skin. The pulp is orange-yellow and strongly-flavoured, and it has a delicate texture and contains few fibres. The fruit can withstand storage for long periods, and it ripens from May to June (BAPHIQ, 2004).

Production

Southern Taiwan produces approximately 210,000 tonnes of mangoes per annum, from plantings covering over 20,000 hectares (BAPHIQ, 2004). Mango production in Taiwan occurs predominantly in the counties of Tainan and Pingtung, which produced 84% of the total crop in 2002 (BAPHIQ, 2004). Details of mango production areas and yields for 2002 are given in Table 2 and the counties shown in Figure 1.

Table 2: Mango production areas and yield in Taiwan in 2002 (BAPHIQ, 2004)

County	Production area (ha)	Yield (tonnes)
Tainan	8 084	94 290
Pingtung	8 079	84 963
Kouhsiung	2 330	20 703
Chiayi	342	5 542
Taitung	269	3 046
Taichung	108	1 083
Changhwa	96	889
Others	482	2 850
Total	19 790	213 366

The Taiwanese mango industry has been developing for several decades, and production period and cultivation techniques have been significantly improved (COA, 2005). Mangoes are supplied to domestic and foreign markets from May to November (COA, 2005).

Export of mangoes from Taiwan

Mangoes from Taiwan are exported to Hong Kong, Singapore, mainland China, Japan (COA, 2005) and New Zealand (MAF, 2004). Mangoes account for 12.5% of total fruit exports from Taiwan (Wu, 2004).

Figure 1: Map of administrative divisions of Taiwan showing the principal mango production counties of Tainan and Pingtung and other production areas



Source: <http://www.world-gazetteer.com>

METHOD FOR PEST RISK ANALYSIS

An outline of the methodology used for PRA is given to provide the context for the technical information that is provided later in this report. In accordance with the *International Standards for Phytosanitary Measures No. 11: Pest Risk Analysis for Quarantine Pests including Analysis of Environmental Risks and Living Modified Organisms* (ISPM 11) (FAO, 2004), this pest risk analysis comprises three discrete stages:

- Stage 1: initiation
- Stage 2: pest risk assessment
- Stage 3: pest risk management

Stage 1: Initiation

The aim of the initiation stage is to identify the pest(s) and pathway(s) (e.g. commodity imports) that are of quarantine concern and should be considered for risk analysis in relation to the identified PRA area.

Stage 2: Pest Risk Assessment

The pest risk assessment is carried out in accordance with International Plant Protection Convention (IPPC) standards and reported in the following steps:

- pest categorisation;
- assessment of probability of entry, establishment or spread; and
- assessment of potential consequences (including environmental impacts).

Pest categorisation

Pest categorisation is a process to examine, for each pest, whether the criteria for a quarantine pest are satisfied. The process of pest categorisation is summarised by the IPPC in the five elements outlined below:

- identity of the pest;
- presence or absence in the endangered area;
- regulatory status;
- potential for establishment and spread in the PRA area; and
- potential for economic consequences in the endangered area.

The pests are categorised according to their presence or absence, their association with the commodity pathway, their potential to establish or spread, and their potential for economic

consequences. Categorisation for potential of establishment and spread and potential for economic consequences was expressed using the terms ‘feasible’ / ‘not feasible’, and ‘significant’ / ‘not significant’, respectively.

Pests found to have potential for entry, establishment or spread and potential for economic consequences satisfy the criteria for a quarantine pest. A quarantine pest is defined as "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, 2002). The methodology used for the detailed risk assessments conducted on the quarantine pests is given below.

Assessment of the probability of entry, establishment or spread

Details of assessing the ‘probability of entry’, ‘probability of establishment’ and ‘probability of spread’ of a pest are given in *ISPM 11* (FAO, 2004).

Assessing the probability of entry requires an analysis of each of the pathways with which a pest may be associated, from its origin to distribution in the PRA area. The probability of entry may be divided for assessment purposes into the following components:

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

The probability of distribution: the probability that the pest will be distributed (as a result of the processing, sale or disposal of the commodity) to the endangered area, and subsequently be transferred to a suitable site on a susceptible host.

In breaking down the probability of entry into these two components, Biosecurity Australia has not altered the original meaning. The two components have been identified and separated to enable onshore and offshore pathways to be described individually.

The probability of establishment is estimated on the basis of availability, quantity and distribution of hosts in the PRA area; environmental suitability in the PRA area; potential for adaptation of the pest; reproductive strategy of the pest; method of pest survival; and cultural practices and control measures. Similarly, the probability of spread is estimated on the basis of suitability of the natural and/or managed environment for natural spread of the pest; presence of natural barriers; the potential for movement with commodities or conveyances; intended use of the commodity; potential vectors of the pest in the PRA area; and potential natural enemies of the pest in the PRA area.

Qualitative likelihoods are assigned to the probability of entry (comprising an importation step and a distribution step), the probability of establishment and the probability of spread. Likelihoods are categorised according to a descriptive scale from ‘high’ to ‘negligible’ as shown in Table 3.

Table 3: Nomenclature for qualitative likelihoods

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

The likelihoods of entry, of establishment and of spread are combined using the tabular matrix shown in Table 4.

Table 4: Matrix of rules for combining descriptive likelihoods

	High	Moderate	Low	V. Low	E. Low	Negligible
High	High	Moderate	Low	V. Low	E. Low	Negligible
Moderate		Low	Low	V. Low	E. Low	Negligible
Low			V. Low	V. Low	E. Low	Negligible
Very low				E. Low	E. Low	Negligible
E. low					Negligible	Negligible
Negligible						Negligible

Assessment of consequences

The basic requirements for the assessment of consequences are described in the *SPS Agreement*, in particular Article 5.3 and Annex A. Further detail on assessing consequences is given in the “*potential economic consequences*” section of *ISPM 11*. This ISPM separates the consequences into “direct” and “indirect” and provides examples of factors to consider within each. In this PRA, the term “consequence” is used to reflect the “relevant economic factors”/“associated potential biological and economic consequences” and “potential economic consequences” terms as used in the *SPS Agreement* and *ISPM 11*, respectively.

The direct and indirect consequences were estimated based on four geographic levels. The terms ‘local’, ‘district’, ‘regional’ and ‘national’ are defined as:

Local: an aggregate of households or enterprises — e.g. 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, such as the ‘North West Slopes and Plains’ or ‘Far North Queensland’
- Region:** a geographically or geopolitically associated collection of districts — generally a state, although there may be exceptions with larger states such as Western Australia
- National:** Australia-wide

The consequence was described as:

- ‘*unlikely to be discernible*’ is not usually distinguishable from normal day-to-day variation in the criterion;
- ‘*minor significance*’ is not expected to threaten economic viability, but would lead to a minor increase in mortality/morbidity or a minor decrease in production. For non-commercial factors, the consequence is not expected to threaten the intrinsic ‘value’ of the criterion — though the value of the criterion would be considered as ‘disturbed’. Effects would generally be reversible.
- ‘*significant*’ consequence would threaten economic viability through a moderate increase in mortality/morbidity, or a moderate decrease in production. For non-commercial factors, the intrinsic ‘value’ of the criterion would be considered as significantly diminished or threatened. Effects may not be reversible; and
- ‘*highly significant*’ would threaten economic viability through a large increase in mortality/morbidity, or a large decrease in production. For non-commercial factors, the intrinsic ‘value’ of the criterion would be considered as severely or irreversibly damaged.

The values are translated into a qualitative score (A–F) using the schema outlined in Table 5.

Table 5: The assessment of local, district, regional and national consequences

Impact score	Level			
	Local	District	Regional	National
F	-	-	-	Highly significant
E	-	-	Highly significant	Significant
D	-	Highly significant	Significant	Minor
C	Highly significant	Significant	Minor	Unlikely to be discernible
B	Significant	Minor	Unlikely to be discernible	Unlikely to be discernible
A	Minor	Unlikely to be discernible	Unlikely to be discernible	Unlikely to be discernible

The overall consequence for each pest was achieved by combining the qualitative scores (A–F) for each direct and indirect consequence using a series of decision rules. These rules

are mutually exclusive, and are addressed in the order that they appeared in the list — for example, if the first rule does not apply, the second rule is considered. If the second rule does not apply, the third rule is considered and so on until one of the rules applies:

- Where the impact score of a pest with respect to any direct or indirect criterion is ‘F’, the overall consequences are considered to be ‘extreme’.
- Where the impact scores of a pest with respect to more than one criterion are ‘E’, the overall consequences are considered to be ‘extreme’.
- Where the impact score of a pest with respect to a single criterion is ‘E’ and the impact scores of a pest with respect to each remaining criterion is ‘D’, the overall consequences are considered to be ‘extreme’.
- Where the impact score of a pest with respect to a single criterion is ‘E’ and the impact scores of a pest with respect to remaining criteria are not unanimously ‘D’, the overall consequences are considered to be ‘high’.
- Where the impact scores of a pest with respect to all criteria are ‘D’, the overall consequences are considered to be ‘high’.
- Where the impact score of a pest with respect to one or more criteria is ‘D’, the overall consequences are considered to be ‘moderate’.
- Where the impact scores of a pest with respect to all criteria are ‘C’, the overall consequences are considered to be ‘moderate’.
- Where the impact score of a pest with respect to one or more criteria is considered ‘C’, the overall consequences are considered to be ‘low’.
- Where the impact scores of a pest with respect to all criteria are ‘B’, the overall consequences are considered to be ‘low’.
- Where the impact score of a pest with respect to one or more criteria is considered ‘B’, the overall consequences are considered to be ‘very low’.
- Where the impact scores of a pest with respect to all criteria are ‘A’, the overall consequences are considered to be ‘negligible’.

Method for determining the unrestricted risk estimate

The unrestricted risk estimate for each pest is determined by combining the likelihood estimates of entry, of establishment and of spread with the overall potential consequences. This is done using the risk estimation matrix shown in Table 6. The cells of this matrix describe the product of likelihood of entry, establishment or spread and consequences of entry, establishment or spread.

Table 6: Risk estimation matrix

Likelihood of entry, establishment or spread	<i>High likelihood</i>	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
	<i>Moderate</i>	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
	<i>Low</i>	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
	<i>Very low</i>	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
	<i>Extremely low</i>	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
	<i>Negligible likelihood</i>	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk
		<i>Negligible impact</i>	<i>Very low</i>	<i>Low</i>	<i>Moderate</i>	<i>High</i>	<i>Extreme impact</i>
Consequences of entry, establishment or spread							

Australia's appropriate level of protection (ALOP)

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

Like many other countries, Australia expresses its ALOP in qualitative terms. Australia's ALOP, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 6 marked 'very low risk' represents Australia's ALOP.

Stage 3: Pest Risk Management

Risk management describes the process of identifying and implementing measures to manage risks so as to achieve Australia's ALOP, while ensuring that any negative effects on trade are minimised.

To implement risk management appropriately, it is necessary to formalise the difference between 'unrestricted' and 'restricted' risk estimates. Unrestricted risk estimates are those derived in the absence of specific risk management measures, or following only baseline risk management procedures based on commercial production practices. By contrast, restricted or mitigated risk estimates are those derived when 'risk management' is applied.

The conclusions from pest risk assessment are used to decide whether risk management is required and if so, the strength of measures to be used. Where the unrestricted risk estimate

does not maintain Australia's ALOP, risk management measures are required to reduce this risk to a very low level. Since zero-risk is not a reasonable option, the guiding principle for risk management is to manage risk to achieve the required degree of safety that can be justified and is feasible within the limits of available options and resources.

ISPM 11 provides details on the identification and selection of appropriate risk management options and notes that the choice of measures should be based on their effectiveness in reducing the probability of the introduction of the pest.

Examples given of measures commonly applied to traded commodities include:

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

Risk management measures were identified for each pest that does not meet the ALOP as required and are presented in the Pest Risk Management section of this report. The pests that do not meet the ALOP require the use of risk management measures in addition to the standard commercial practices. The recommended phytosanitary regulations based on these measures are presented in the Final Import Conditions section of this report.

PEST RISK ANALYSIS

Stage 1: Initiation

Initiation of this PRA followed a market access request for mangoes (*Mangifera indica* L.) from Taiwan into Australia received from BAPHIQ in February and June 2003.

A list of pests likely to be associated with mangoes from Taiwan (i.e. the biosecurity risk pathway) was generated from information supplied by BAPHIQ, literature and database searches. This list was used in this PRA.

In this PRA, the 'PRA area' is defined as Australia for the pests that do not occur in Australia or in the case of regional quarantine pests, the 'PRA area' is defined as the area of Australia that has regional freedom from the pest. The 'endangered area' is defined as any area within Australia, where susceptible hosts are present and in which ecological factors favour the establishment of a pest that might be introduced in association with mangoes from Taiwan. The pathway in this PRA is considered to be fresh mango fruit for human consumption from export orchards in Taiwan.

Stage 2: Pest Risk Assessment

Pest categorisation

The quarantine pests of mangoes from Taiwan have been determined through a comparison of the pests recorded on mangoes in Taiwan, and those recorded in the previous assessments of mangoes from the Philippines and India (draft) (AQIS, 1999; DAFF, 2004) and those known to occur in Australia. Pests were first categorised according to their presence or absence in Australia and presence on the fresh fruit pathway under consideration (Appendix 1) and secondly on their potential for establishment and spread and associated potential for consequences (Appendix 2). Pests that did not meet the definition of a quarantine pest were not considered further in the PRA process.

Nineteen quarantine pests, determined through the pest categorisation process, are listed in Table 7. These pests require detailed risk assessment as they meet the IPPC criteria for a quarantine pest, specifically:

- the pest is known to be associated with mangoes in Taiwan;
- the pest is absent from Australia, or has a limited distribution and is under official control;
- the pest has the potential for being on the pathway of fresh mango fruit;
- the pest has the potential for establishment and spread in the PRA area; and

- the pest has the potential for consequences.

Table 7: Quarantine pests of mangoes from Taiwan (species in bold text have not been previously assessed in AQIS (1999) or DAFF (2004))

Pest Type	Common name
ARTHROPODS	
Diptera (fruit flies)	
<i>Bactrocera cucurbitae</i> (Coquillett, 1899) [Diptera: Tephritidae]	melon fruit fly
<i>Bactrocera dorsalis</i> (Hendel, 1912) [Diptera: Tephritidae]	Oriental fruit fly
<i>Bactrocera latifrons</i> (Hendel, 1915) [Diptera: Tephritidae]	solanum fruit fly
<i>Bactrocera tau</i> (Walker) [Diptera: Tephritidae]	fruit fly
Hemiptera (armoured scales, soft scales, mealybugs, aphids)	
<i>Abgrallaspis cyanophylli</i> (Signoret, 1869) [Hemiptera: Diaspididae]	cyanophyllum scale
*<i>Aonidomytilus albus</i> (Cockerell) [Hemiptera: Diaspididae]	tapioca scale
<i>Lepidosaphes laterochitinsa</i> (Green) [Hemiptera: Diaspididae]	armoured scale
<i>*Milviscutulus mangiferae</i> (Green, 1889) [Hemiptera: Coccidae]	mango shield scale
<i>Parlatoria pseudaspidotus</i> (Lindinger, 1905) [Hemiptera: Diaspididae]	vanda orchid scale
<i>Planococcus lilacinus</i> (Cockerell, 1905) [Hemiptera: Pseudococcidae]	coffee mealybug
<i>Protopulvinaria pyriformis</i> (Cockerell) [Hemiptera: Coccidae]	pyriform scale
<i>Pseudococcus cryptus</i> (Hempel) [Hemiptera: Pseudococcidae]	citriculus mealybug
<i>Pseudococcus jackbeardsleyi</i> Gimpel & Miller [Hemiptera: Pseudococcidae]	Jack Beardsley mealybug
<i>Rastrococcus spinosus</i> (Robinson, 1918) [Hemiptera: Pseudococcidae]	Philippine mango mealybug
<i>Toxoptera odinae</i> (van der Goot, 1917) [Hemiptera: Aphididae]	mango aphid
<i>Unaspis acuminata</i> (Green) [Hemiptera: Diaspididae]	unaspis scale
Lepidoptera (lymantrid moth)	
<i>Orgyia australis postica</i> (Walker) [Lepidoptera: Lymantridae]	cocoa tussock moth
Thysanoptera (thrips)	
<i>Rhipiphorothrips cruentatus</i> Hood, 1919 [Thysanoptera: Thripidae]	mango thrips
PATHOGENS	
Fungi	
*<i>Elsinoë mangiferae</i> Bitancourt & Jenkins [Myriangiales; Elsinoaceae]	mango scab

*Western Australia only – this species is a quarantine pest for the State of Western Australia due to its absence.

Risk assessments for quarantine pests

Detailed risk assessments are presented in this PRA for the quarantine pests identified in the pest categorisation stage. Risk assessments were based on groups of pests (e.g. fruit flies) where the pest species share similar biological characteristics, behaviour on the host and pathway and potential phytosanitary considerations. Risk assessments are presented for the following groups of pests: fruit flies (four species); armoured scales (5 species); soft scales (2 species); mealybugs (4 species); mango aphid; cocoa tussock moth; mango thrips and mango scab.

Each risk assessment involved the ‘assessment of the probability of entry, establishment or spread’ and ‘assessment of consequences’ as described in the Method for Pest Risk Analysis. The unrestricted risk posed by each quarantine pest was estimated by combining the probabilities of entry, of establishment and of spread with the estimate of associated potential consequences. The unrestricted risk estimates were then compared with Australia’s ALOP to determine which quarantine pests presented an unacceptable level of risk and required risk mitigation options.

Probability estimates of entry, of establishment and of spread and potential consequences are supported by relevant biological information. Detailed information on each quarantine pest within each group is provided in the data sheets in Appendix 3.

The risk assessments assumed standard cultivation, harvesting and packing activities in the commercial production of mangoes (e.g. in-field hygiene and management of pests, cleaning and hygiene during packing, and commercial quality control activities).

Arthropod Pests

Fruit flies

The Tephritidae (fruit flies) is one of the largest families of flies, containing at least 4000 species (White and Elson-Harris, 1992). Adults possess one pair of wings, well-developed legs, and they reproduce sexually. Females possess a long, extendable ovipositor, which they use to deposit eggs within host fruit or between parts of the host flower, depending on the species. Fruit flies are some of the most serious pests of many fruit and vegetable crops.

The fruit flies [Diptera: Tephritidae] examined in this pest risk analysis are:

- *Bactrocera cucurbitae* (Coquillett, 1899)– melon fruit fly
- *Bactrocera dorsalis* (Hendel, 1912) – Oriental fruit fly
- *Bactrocera latifrons* (Hendel, 1915) – solanum fruit fly
- *Bactrocera tau* (Walker) – fruit fly

NOTE: Due to the recognised universal economic importance of *Bactrocera dorsalis*, it was used as the basis for the risk assessment and development of listed risk management measures for all fruit fly species identified. *Bactrocera cucurbitae*, *Bactrocera dorsalis* and *Bactrocera tau* have been assessed previously (AQIS, 1999; DAFF, 2004).

Introduction and spread potential

Probability of importation

The likelihood that fruit flies will arrive in Australia with the importation of fresh mangoes from Taiwan: **High**.

- *B. dorsalis* infests mango fruit in the entire Asian-Pacific region (Srivastava, 1997). Oviposition by *B. dorsalis* causes an inconspicuous puncture because its colour blends with the colour of dark green fruit (Srivastava, 1997), although it may be visible in some yellow and pale brown mango varieties.
- Eggs are deposited beneath the skin of the fruit (CAB International, 2005) and larvae feed within the fruit for a few days after hatching. They would be difficult to detect pre-emergence.
- Larvae can survive within picked fruit and are likely to be present in fruit packed for export. Infested fruit are unlikely to be detected during sorting, packing and quality inspection procedures in terms of blemishes, bruising or damage to the skin. The procedures are not specifically directed at the detection of pests.
- Procedures undertaken within the packhouse including routine washing, but surface washing would not remove eggs or larvae present within the fruit.

Probability of distribution

The likelihood that fruit flies will be distributed as a result of the processing, sale or disposal of fresh mangoes from Taiwan, to the endangered area: **High**.

- It is likely that different life stages of *B. dorsalis* would survive storage and transportation because eggs can tolerate cold storage temperatures and adults tolerate temperatures as low as 2°C (EPPO, 2005).
- Fruit infested with undetected eggs and larvae are likely to be distributed throughout Australia for retail sale. Waste from such fruit provides a source of infestation to suitable hosts; *Bactrocera dorsalis* has a wide host range (Allwood *et al.*, 1999).
- Larvae can develop into adult flies, that are strong flyers (Fletcher, 1989) and able to move directly from fruit into the environment to find a suitable host. Some *Bactrocera* spp. may fly 50-100 km (Fletcher, 1989).

Probability of entry (importation × distribution)

The likelihood that fruit flies will enter Australia as a result of trade in fresh mangoes from Taiwan and be distributed in a viable state to the endangered area: **High**.

The overall probability of entry is determined by combining the likelihoods of importation and of distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Probability of establishment

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

- Incursions of exotic fruit fly species of the *B. dorsalis* complex have previously occurred and subsequently been eradicated. *Bactrocera papayae* was detected near Cairns, northern Queensland in 1995. It was eradicated using a program of male annihilation and protein bait spraying (Cantrell *et al.*, 2002). This example demonstrates that fruit fly species from the *B. dorsalis* complex can establish in Australia.
- Hosts of *B. dorsalis* are widely distributed throughout Australia. Adults may live for many months and the potential fecundity of females of *B. dorsalis* in the laboratory is well over 1000 eggs (Fletcher, 1989).
- The *B. dorsalis* complex of fruit flies includes papaya fruit fly and therefore reproductive biology of *B. dorsalis* would be similar (CAB International, 2005).

Probability of spread

The likelihood that fruit flies will spread based on a comparative assessment of those factors in the area of origin and in Australia considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- Flight of adults and the transport of infested fruit are the main means of dispersal of fruit flies to previously uninfested areas. Fruit fly species of the *B. dorsalis* complex have a wide host range of both commercial and wild species (EPPO, 2005) which are widespread in Australia.
- The incursion of *B. papayae* into northern Australia in 1995 is indicative of the ability of introduced fruit fly species of the *B. dorsalis* complex to spread. Initially, the infested area covered 4,500 km² (Allwood, 1995), and was centered on Cairns. The declared pest quarantine area later expanded to 78,000 km² of north Queensland, including urban areas, farms, rivers, coastline and a large part of the Wet Tropics World Heritage Area (Cantrell *et al.*, 2002). *Bactrocera dorsalis* and other *Bactrocera* spp. are expected to have a similar capacity to spread in Australia as a result of their similarity to *B. papayae* and their wide host range.

Probability of entry, establishment or spread

The overall likelihood that fruit flies will enter Australia as a result of trade in fresh mangoes from Taiwan, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **High**.

The probability of entry, establishment or spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Consequences

Consequences (direct and indirect) of fruit flies: **High**.

Criterion	Estimate
<i>Direct consequences</i>	
Plant life or health	D — Fruit flies can cause direct harm to a wide range of plant hosts (e.g: <i>Citrus</i> spp., <i>Prunus</i> spp., <i>Malus pumila</i> , <i>Mangifera indica</i>) and are estimated to have highly significant consequences at the district level and consequences of minor significance at the national level.
Any other aspects of the environment	B — Fruit flies introduced into a new environment will compete for resources with native species. There may be significant consequences of these pests for native plants at a local level, which would be unlikely to be discernible at a national level.
<i>Indirect consequences</i>	
Eradication, control etc.	E — A control program would add considerably to the cost of production of the host fruit, costing between \$200 and \$900 per hectare, depending on the cultivar of fruit produced and the time of harvest (Anon., 1991). In 1995, the <i>B. papayae</i> (papaya fruit fly) eradication program using male annihilation and protein bait spraying cost AU\$35 million (SPC, 2002). Fruit flies are estimated to have significant consequences at the national level and highly significant consequences at the regional level.
Domestic trade	D — The presence of fruit flies in commercial production areas will have a significant effect at the regional level because of any resulting interstate trade restrictions on a wide range of commodities.
International trade	D — Fruit flies are regarded as the most destructive pests of horticultural crops. Although they can cause considerable yield losses in orchards and suburban backyards, the major consequence for Australian horticultural industries would be the negative effect they have on gaining and maintaining export markets. For example, when the papaya fruit fly outbreak occurred in north Queensland, impacts on trade affected the whole of Australia. In the first two months of the papaya fruit fly eradication campaign, about \$600,000 worth of exports were interrupted (Cantrell <i>et al.</i> , 2002). Within a week of the papaya fruit fly outbreak being declared, Japan ceased imports of mangoes at a cost of about \$570,000, New Zealand interrupted its \$30,000 banana trade and the Solomon Islands completely stopped importing fruit and vegetables from Queensland (Cantrell <i>et al.</i> , 2002). Fruit flies are estimated to have consequences of minor significance at the national level.
Environment	C — Pesticides required to control fruit flies are estimated to have consequences that are significant at the district level.

Unrestricted risk estimate

The unrestricted risk estimate as determined by combining the overall ‘probability of entry, establishment or spread’ with the ‘consequences’ using the risk estimation matrix (Table 6): **High**.

Armoured scales

Armoured, or hard scales, damage the host plant by sucking sap through their stylets. They do not produce honeydew, but their feeding can blemish fruit or cause leaf drop (Smith *et al.*, 1997). They can inject toxins into plant tissues and high populations can reduce plant vigour or cause the death of trees (Beardsley and Gonzalez, 1975; Smith *et al.*, 1997). The reproductive rates for armoured scales are weather dependent and more generations are produced in tropical climates.

The armoured scales [Hemiptera: Diaspididae] examined in this pest risk analysis are:

- **Abgrallaspis cyanophylli* (Signoret, 1869) - cyanophyllum scale, red scale
- *Aonidomytilus albus* (Cockerell) - tapioca scale
- *Lepidosaphes laterochitinosus* (Green) – armoured scale
- *Parlatoria pseudaspidotus* (Lindinger, 1905) - vanda orchid scale
- *Unaspis acuminata* (Green) – unaspis scale

* This species is a quarantine pest for Western Australia.

These armoured scale species have been grouped due to their similar biology and behaviour on the hosts. *Abgrallaspis cyanophylli* has previously been assessed (DAFF, 2004).

Introduction and spread probability

Probability of importation

The likelihood that armoured scales will arrive in Australia with the importation of fresh mangoes from Taiwan: **High**.

- Armoured scale species are considered present on the import pathway. Although usually causing only minor damage to mango in Taiwan, they may occasionally cause heavy damage (Lee, 1988).
- First instar nymphs (or crawlers) are capable of movement onto fruit where they permanently attach and commence feeding (Beardsley and Gonzalez, 1975). Subsequent instars are sessile (CAB International, 2005). Therefore, they may be difficult to remove by cleaning (Taverner and Bailey, 1995).
- Armoured scales construct an external covering or ‘scale’, which protects against physical and chemical attack because of its hardness and impermeability (Foldi,

1990). Hence, commercial fruit cleaning procedures undertaken within the packhouse are unlikely to remove or eliminate all viable scales (Foldi, 1990).

- Inspection procedures carried out within the packhouse are concerned primarily with fruit quality with regard to blemishes, bruising or damage to the skin. These procedures are not specifically directed at the detection of small arthropod pests present on the fruit surface, especially at low levels.
- Adults and crawlers are likely to survive within the storage and transport environment; the fruit would provide an ample food supply during transit.

Probability of distribution

The likelihood that armoured scales will be distributed as a result of the processing, sale or disposal of fresh mangoes from Taiwan, to the endangered area: **Moderate**.

- Infested fresh mango fruit are likely to be distributed throughout Australia within the retail sale pathway. Although, the intended use is human consumption waste material (e.g. mango skin) would be generated and infested plant material may be disposed within the environment.
- Dispersal of crawlers (first-instar nymphs) is accomplished mainly by active wandering and the wind (Beardsley and Gonzalez, 1975). Birds, insects and other animals, including humans may act as vectors (Beardsley and Gonzalez, 1975).
- Armoured scales are polyphagous and all life stages survive in the environment for some time, they may be distributed and transferred to a suitable host.
- Crawlers are the primary dispersal life stage as later instars are sessile and adult females are flightless and remain on the host. While adult males are capable of weak flight they cannot feed and live only a few hours (Beardsley and Gonzalez, 1975; CAB International, 2005).
- The ability of armoured scales to disperse is moderated by the lack of an active longer range dispersal mechanism.

Probability of entry (importation × distribution)

The likelihood that armoured scales will arrive in Australia as a result of trade in fresh mangoes from Taiwan, and be distributed to the endangered area: **Moderate**.

The overall probability of entry is determined by combining the likelihoods of importation and of distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 4).

Probability of establishment

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

- Armoured scales are polyphagous and host plants are common in Australia (e.g. citrus and mango), particularly in the warmer subtropical and tropical regions.
- Existing control programs (e.g. application of broad spectrum pesticides) may control armoured scales on some hosts, but may not be effective on hosts where specific integrated pest management programs are used.
- Reproduction can be either sexual or asexual (without fertilisation) (CAB International, 2005).
- It is unlikely that armoured scales would be contained by agronomic management practices or by regulation.

Probability of spread

The likelihood that armoured scales will spread based on a comparative assessment of those factors in the area of origin and in Australia considered pertinent to the expansion of the geographical distribution of the pest: **Moderate**.

- Adults and nymphs have limited mobility but may be moved within and between orchards (or other commercial production sites) with the movement of equipment, personnel and infested plant material (Dreistadt *et al.*, 1994).
- Crawlers may be moved within and between plantations by the movement of infested plant material, vectors and wind (Beardsley and Gonzalez, 1975; Greathead, 1990).
- If second and subsequent generations of armoured scales become established on commercial, susceptible household and wild host plants, they are likely to persist indefinitely and to spread progressively over time. This spread would be assisted by wind dispersal, vectors and by the movement of infested plant material (Beardsley and Gonzalez, 1975).
- The ability of armoured scales to spread is moderated by the lack of an active longer range dispersal mechanism.

Probability of entry, establishment or spread

The overall likelihood that armoured scales will enter Australia as a result of trade in fresh mangoes from Taiwan, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **Low**.

The probability of entry, establishment or spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Consequences

Consequences (direct and indirect) of armoured scales: **Low**

Criterion	Estimate
<i>Direct consequences</i>	
Plant life or health	C — Armoured scales can cause direct harm to a wide range of host plants, affecting fruit quality and plant health. Armoured scales are polyphagous and host plants are common in Australia (e.g. citrus, mango). Armoured scales are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the regional level.
Any other aspects of the environment	A — Armoured scales introduced into a new environment will compete for resources with native species. They are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the local level.
<i>Indirect consequences</i>	
Eradication, control etc.	C — Programs to minimise the impact of these pests on host plants are likely to be costly and include pesticide applications and crop monitoring. Armoured scales are estimated to have consequences that are unlikely to be discernible at the national level and significant at the district level.
Domestic trade	B — The presence of these pests in commercial production areas may have a significant effect at the local level due to any resulting interstate trade restrictions on a wide range of commodities. These restrictions may lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	B — The presence of these pests in commercial production areas of various export commodities (e.g. citrus, mango) may have an effect due to possible limitations to access to overseas markets where these pests are absent.
Environment	A — Although additional pesticide applications would be required to control these pests on susceptible crops, this is not considered to have significant consequences for the environment.

Unrestricted risk estimate

The unrestricted risk estimate as determined by combining the overall ‘probability of entry, establishment or spread’ with the ‘consequences’ using the risk estimation matrix (Table 6): **Very low**.

Soft scales

Soft scales damage host plants by sucking nutrients from plant parts, and excreting large amounts of sugary honeydew onto fruit and leaves (Smith *et al.*, 1997). The main economic damage caused by soft scales is from the downgrading of fruit quality because

of sooty mould fungus growing on the honeydew (Smith *et al.*, 1997). Heavy infestations can reduce tree vigour and rates of photosynthesis.

The soft scales [Hemiptera: Coccidae] examined in this pest risk analysis are:

- **Milviscutulus mangiferae* (Green, 1889) - mango shield scale
- *Protopulvinaria pyriformis* (Cockerell) - pyriform scale

*This species is a quarantine pest for the State of Western Australia.

These two soft scale species have been grouped due to their similar biology and the nature of their physical presence and behaviour on hosts. *Milviscutulus mangiferae* has been previously assessed (DAFF, 2004)

Introduction and spread potential

Probability of importation

The likelihood that soft scales will arrive in Australia with the importation of fresh mangoes from Taiwan: **High**

- Soft scales are likely to survive storage and transport as the fruit would provide an ample food supply during transit.
- Adult males of *M. mangiferae* have well developed functional legs (Giliomee, 1997) as do first instar nymphs which exhibit considerable mobility upon hosts (Ben-Dov, 1997; Williams, 1997)
- First instar nymphs permanently attach and commence feeding on plant parts including fruit. Therefore, they may be difficult to remove or detect during fruit sorting, especially at low population levels (Taverner and Bailey, 1995).
- Soft scales secrete very little wax compared to armoured scales (Mau and Kessing, 1992), but this still provides some level of protection against physical and chemical attack.
- Inspection procedures carried out within the packhouse are concerned primarily with fruit quality with regard to blemishes, bruising or damage to the skin. These procedures are not specifically directed at the detection of small arthropod pests present on the fruit surface, especially if present in low numbers.

Probability of distribution

The likelihood that soft scales will be distributed as a result of the processing, sale or disposal of fresh mangoes from Taiwan, to the endangered area: **Moderate**.

- Adults and crawlers are likely to survive within the storage and transport environment; the fruit would provide an ample food supply during transit.

- Gravid females would need to be carried onto hosts by vectors such as people or animals. The first instar is the main means of dispersal, by active crawling over short distances and passive dispersal by wind and animals (Greathead, 1997). Dispersal of first instar by wind can occur over considerable distances (Greathead, 1997).
- Infested fresh mango fruit are likely to be distributed throughout Australia through the retail sale pathway. Although the intended use is human consumption waste material (e.g. mango skin) would be generated and infested plant material may be disposed within the environment.

Probability of entry (importation × distribution)

The likelihood that soft scales will arrive in Australia as a result of trade in fresh mangoes from Taiwan, and be distributed to the endangered area: **Moderate**.

The overall probability of entry is determined by combining the likelihoods of importation and of distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Probability of establishment

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

- Soft scales are polyphagous and host plants are common in Australia (e.g. citrus, mango, eucalypts), particularly in the warmer subtropical and tropical regions.
- Existing control programs (e.g. application of broad spectrum pesticides) may control soft scales on some hosts, but may not be effective on hosts where specific integrated pest management programs are used.
- Soft scales have a high reproductive rate and *Protopulvinaria pyriformis* and *M. mangiferae* reproduce parthenogenetically (Ben-Dov, 2005).

Probability of spread

The likelihood that soft scales will spread based on a comparative assessment of those factors in the area of origin and in Australia considered pertinent to the expansion of the geographical distribution of the pest: **Moderate**.

- *Protopulvinaria pyriformis* and *M. mangiferae* reproduce parthenogenetically (Ben-Dov, 2005)
- If second, and subsequent, generations of soft scales become established on host plants, they are likely to persist indefinitely and to spread progressively over time.

This spread would be assisted by wind dispersal, vectors and by the movement of plant material (Greathead, 1997). It is very unlikely that soft scales could be contained by agronomic management practices or by regulation.

- Gravid females and crawlers may be moved within and between plantations by birds, on human clothing and in the hair of mammals. Crawlers can be dispersed by wind currents over considerable distances (Greathead, 1997).

Probability of entry, establishment or spread

The overall likelihood that soft scales will enter Australia as a result of trade in fresh mangoes from Taiwan, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **Low**.

The probability of entry, establishment or spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Consequences

Consequences (direct and indirect) of soft scales: **Low**.

Criterion	Estimate
<i>Direct consequences</i>	
Plant life or health	C — Soft scales can cause direct harm to a wide range of plant hosts, affecting fruit quality and whole plant health. Fruit quality can be reduced by the presence of secondary sooty mould. These soft scale species are polyphagous and host plants are common in Australia (e.g. citrus, mango). Soft scales are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the regional level.
Any other aspects of the environment	A — Soft scales introduced into a new environment will compete for resources with native species. They are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the local level.
<i>Indirect consequences</i>	
Eradication, control etc.	C — Programs to minimise the impact of these pests on host plants are likely to be costly and include pesticide applications and crop monitoring. Existing control programs (e.g. application of broad spectrum pesticides) may control soft scales on some hosts, but may not be effective on hosts where specific integrated pest management programs are used. Soft scales are considered to have consequences that are unlikely to be discernible at the national level and significant at the district level.
Domestic trade	B — The presence of these pests in commercial production areas is likely to have a significant effect at the local level because of any resulting interstate trade restrictions on various commodities. These restrictions may lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	B — The presence of these pests in commercial production areas of a range of export commodities (e.g. citrus, mango) may have a significant effect at the local level because of any limitations to access to overseas markets

where these pests are absent.

Environment

A — Although additional pesticide applications would be required to control these pests on susceptible crops, this is not considered to have significant consequences for the environment.

Unrestricted risk estimate

The unrestricted risk estimate as determined by combining the overall ‘probability of entry, establishment or spread’ with the ‘consequences’ using the risk estimation matrix (Table 6): **Very low**.

Mealybugs

Mealybugs injure host plants by sucking sap through tubular stylets, and by excreting large amounts of sugary honeydew onto fruit and leaves. Heavy infestations may damage plants directly. Sooty mould fungus growth on the honeydew secretions can render the fruit unmarketable, reduce the photosynthetic efficiency of leaves and cause leaf drop. Many mealybug species pose particularly serious problems to agriculture when introduced into new areas of the world where their natural enemies are not present (CAB International, 2005).

The mealybugs [Hemiptera: Pseudococcidae] examined in this pest risk analysis are:

- *Planococcus lilacinus* (Cockerell, 1905) – coffee mealybug
- *Pseudococcus cryptus* (Hempel) – citriculus mealybug
- *Pseudococcus jackbeardsleyi* Gimpel & Miller – Jack Beardsley mealybug
- *Rastrococcus spinosus* (Robinson, 1918) – Philippine mango mealybug.

These mealybug species have been grouped due to their similar biology and the nature of their physical presence and behaviour on hosts. Mealybugs *Planococcus lilacinus* and *Rastrococcus spinosus* have been previously assessed (DAFF, 2004).

Introduction and spread potential

Probability of importation

The likelihood that mealybugs will arrive in Australia with the importation of fresh mangoes from Taiwan: **High**.

- Infestations on mango usually begin on the underside of leaves on terminal shoots. The mealybugs spread to young shoots, flowers and fruit as their population increases (Myfruits, 2004).
- Mealybugs have limited mobility, are small (0.5-4 mm) and are often inconspicuous.
- Inspection procedures carried out in the packhouse are focused primarily on fruit

quality with regard to blemishes, bruising or damage to the skin. Although all fruit is visually inspected, the procedures are not specifically directed at the detection of small arthropod pests present on the fruit surface.

- Routine cleaning procedures undertaken within packhouses may not remove all mealybugs from the fruit surface. Although mealybugs may be affected by the washing solution, they are unlikely to be destroyed by it. This is particularly true of those adult females or nymphs that are protected by waxy cocoons, coatings or coverings.
- Mated adult females of a related species, *R. iceryoides*, can live for 13-23 days and unmated females can live for up to 80 days (Rawat and Jakhmola, 1970). The nymphal period for *P. lilacinus* can survive for up to 25 days (Loganathan and Suresh, 2001). Mealybugs are capable of hibernation during cold periods (Smith *et al.*, 1997).

Probability of distribution

The likelihood that mealybugs will be distributed as a result of the processing, sale or disposal of fresh mangoes from Taiwan, to the endangered area: **Moderate**.

- Mealybugs present on the fruit may survive distribution and be present on waste generated in Australia. Mated adult females of a related species, *R. iceryoides*, can live for 13-23 days and unmated females can live for up to 80 days (Rawat and Jakhmola, 1970). The nymphal stage of *P. lilacinus* can survive for up to 25 days (Loganathan and Suresh, 2001). Mealybugs are capable of hibernation during cold periods (Smith *et al.*, 1997).
- Adult males are winged but fragile and short-lived and do not persist for more than 1-2 days (Mau and Kessing, 1993). The first instar is the main means of dispersal, by active crawling and passive dispersal by wind and animal agents (CAB International, 2005).
- Mealybugs can enter the environment in four ways: adults can be associated with discarded mango skin; first instar nymphs (crawlers) may be discarded with fruit; crawlers can be blown by wind currents (Ben-Dov, 1994) from mangoes at the point of sale or after purchase by consumers; or crawlers can be carried by other vectors, from mangoes at the point of sale or after purchase by consumers.

Probability of entry (importation × distribution)

The likelihood that mealybugs will arrive in Australia as a result of trade in fresh mangoes from Taiwan, and be distributed to the endangered area: **Moderate**.

The overall probability of entry is determined by combining the likelihoods of importation and of distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Probability of establishment

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

- Many mealybugs are considered invasive and have been introduced into new areas and become established (Miller *et al.*, 2002). These mealybug species have shown that they have the ability to establish after being introduced into new environments. For example, *P. lilacinus* is native to the Afrotropical region (Miller *et al.*, 2002) and is now established in the Palaearctic, Malaysian, Oriental, Australasian and Neotropical regions (CAB International, 2005).
- Mealybugs are polyphagous and host plants are common in Australia (e.g. citrus, mango and grapevine).
- Mealybugs have a high reproductive rate. The reproductive strategy and consequent persistence of these pests is based largely on the longevity and fecundity of adult females.
- Unmated females of *R. iceryoides* live for up to 80 days whereas mated females live for 13-23 days. Adult males live for only 1-2 days and start copulating soon after they emerge (Rawat and Jakhmola, 1970). Nymphs are active during the first instar stage and can disperse and locate new hosts by crawling, vectors or the wind before their mobility becomes limited in the remaining nymphal instars.

Probability of spread

The likelihood that mealybugs will spread based on a comparative assessment of those factors in the area of origin and in Australia considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- After second, and subsequent generations, of mealybugs have become established mealybugs are likely to persist indefinitely and to spread progressively over time (Miller *et al.*, 2002).
- Adults and nymphs of mealybugs can be moved within and between plantations with the movement of infested plant material and animal vectors. Crawlers can be dispersed onto other plants by wind and animals (CAB International, 2005).
- Insecticides do not always provide adequate control of mealybugs due to their waxy coating (CAB International, 2005). Heavily infested branches may be pruned to control the pest, especially on the tender branches before flowering begins.

Biological control using natural enemies (i.e. predators and parasitoids), is commonly used to control mealybugs locally in orchards (CAB International, 2005).

- It is unlikely that mealybugs could be contained by agronomic management practices or by regulation.

Probability of entry, establishment or spread

The overall likelihood that mealybugs will enter Australia as a result of trade in fresh mangoes from Taiwan, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **Moderate**.

The probability of entry, establishment or spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 4).

Consequences

Consequences (direct and indirect) of mealybugs: **Low**.

Criterion	Estimate
<i>Direct consequences</i>	
Plant life or health	C — Mealybugs can cause direct harm to a wide range of plant hosts (CAB International, 2005). Fruit quality can be reduced by the presence of secondary sooty mould. Mealybugs are polyphagous and host plants are common in Australia (e.g. citrus, mango, grapevine). Mealybugs are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the regional level.
Any other aspects of the environment	A — Mealybugs introduced into a new environment will compete for resources with native species. They are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the local level.
<i>Indirect consequences</i>	
Eradication, control etc.	C — Programs to minimise the impact of these pests on host plants are likely to be costly and include pesticide applications and crop monitoring. Existing control programs can be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. where specific integrated pest management programs are used). Insecticides do not always provide adequate control of mealybugs because of the waxy coating on the mealybug (CAB International, 2005). Mealybugs are considered to have consequences that are unlikely to be discernible at the national level and significant at the district level.
Domestic trade	B — The presence of these pests in commercial production areas is likely to have a highly significant effect at the local level because of any resulting interstate trade restrictions on a wide range of commodities. These restrictions can lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	C — The presence of these mealybugs in commercial production areas of a wide range of commodities (e.g. citrus, mango, grapevine) could have a significant effect at the district level because of any limitations to access to overseas markets for a range of export fruits where these pests are absent. These pests are all associated with citrus. Australia exports citrus fruit to the USA from the Riverland-Sunraysia-Riverina (R-S-R) area. If these

Environment

mealybugs became established in the R-S-R and other export areas in Australia, citrus trade with the USA and other countries might be compromised.

A — Although additional pesticide applications would be required to control these pests on susceptible crops, this is not considered to have significant consequences for the environment.

Unrestricted risk estimate

The unrestricted risk estimate as determined by combining the overall ‘probability of entry, establishment or spread’ with the ‘consequences’ using the risk estimation matrix (Table 6): **Low**.

Mango Aphid

Aphids belong to the suborder Sternorrhyncha, within the order Hemiptera (Carver *et al.*, 1991). Over 4000 species have been described (Dixon, 1987), and most species live on one or a few species of a particular genus of plants, where they feed on the phloem (Carver *et al.*, 1991). Loss of sap results in stunting, distortion or wilting, especially when large populations of aphids occur on young shoots (Carver *et al.*, 1991).

The aphid [Hemiptera: Aphididae] examined in this pest risk analysis is:

- *Toxoptera odinae* (van der Goot, 1917) – mango aphid

Introduction and spread potential

Probability of importation

The likelihood that *T. odinae* will arrive in Australia with the importation of fresh mangoes from Taiwan: **Low**.

- Individuals would only rarely be found on the fruit pathway as mango aphids suck the sap from the leaves and shoots (Mondal *et al.*, 1976; Shukla and Prasad, 1983).
- Mango aphids are small (1.0-2.5 mm) (Blackman and Eastop, 1984) and may be inconspicuous on fruit.
- Individuals of *T. odinae* are usually attended by ants (Mondal *et al.*, 1976; Blackman and Eastop, 1984). The presence of ants may indicate the presence of aphids, increasing the likelihood of detection of *T. odinae* on infested mango fruit.
- Post harvest grading, cleaning and packing procedures are likely to reduce the incidence of mango aphids on the fruit as the aphids are only anchored to the fruit while feeding.

Probability of distribution

The likelihood that *T. odinae* will be distributed as a result of the processing, sale or disposal of fresh mangoes from Taiwan, to the endangered area: **Low**.

- Aphids feed primarily on the phloem sap (Carver *et al.*, 1991), which is found in plant stems and in veins of leaves.
- Aphids that may occur by chance on the mango fruit would be unlikely to survive storage and transportation and remain viable during distribution in Australia.
- Mangoes may be distributed throughout Australia for retail sale. The intended use of the commodity is human consumption, but waste material would be generated and infested material released to the environment.
- The aphid has both winged and wingless stages (Mondal *et al.*, 1976) enabling some mobility.

Probability of entry (importation × distribution)

The likelihood that *T. odinae* will arrive in Australia as a result of trade in fresh mangoes from Taiwan, and be distributed to the endangered area: **Very low**.

The overall probability of entry is determined by combining the likelihoods of importation and of distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Probability of establishment

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

- *T. odinae* has a wide host range (Mondal *et al.*, 1976; Blackman and Eastop, 1984; Martin, 1989) and known host plants (e.g. mango, magnolia, citrus) are common in Australia.
- *T. odinae* is present in many countries in Asia (Mondal *et al.*, 1976; Blackman and Eastop, 1984; Martin, 1989). The warmer regions of Australia would be highly suited for the survival and reproduction of mango aphid.
- Aphids have a high reproductive rate, and females can reproduce parthenogenetically, i.e. in the absence of males (Carver *et al.*, 1991).
- There is a division of labour, with some stages in the life cycle concentrating on reproduction and others on dispersal (Carver *et al.*, 1991). This may enhance the ability of *T. odinae* to establish in Australia.

Probability of spread

The likelihood that *T. odinae* will spread based on a comparative assessment of those factors in the area of origin and in Australia considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- The long distances between the main Australian commercial mango orchards would make it difficult for aphids to disperse directly from one mango-growing area to another. However, the polyphagous nature of these aphids should enable them to locate suitable hosts inbetween orchards.
- *T. odinae* could be distributed in the environment through eggs and adults being carried on ornamental or crop plants during domestic trade. Immature stages of aphids are known to be transported by wind (Carver *et al.*, 1991).
- Environmental conditions (e.g. temperature, rainfall) similar to those in Taiwan occur in parts of Australia.
- Chemical control of *T. odinae* has been shown to be effective (Shukla and Prasad, 1983). Existing control programs may be effective against *T. odinae* on some hosts, but not all hosts (where specific integrated pest management programs are used).

Probability of entry, establishment or spread

The overall likelihood that *T. odinae* will enter Australia as a result of trade in fresh mangoes from Taiwan, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **Very low**.

The probability of entry, establishment or spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Consequences

Consequences (direct and indirect) of *T. odinae*: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	C — <i>T. odinae</i> can cause direct harm to a wide range of plant hosts (Mondal <i>et al.</i> , 1976; Blackman and Eastop, 1984; Martin, 1989). However, <i>T. odinae</i> is not known to be a disease vector (Blackman and Eastop, 1984). Aphids feed by sucking up plant juices through a food channel in their beaks. Light infestations are usually not harmful to plants, but higher infestations may result in leaf curl (Mondal <i>et al.</i> , 1976), wilting, stunting of shoot growth, and delay in production of flowers and fruit, as well as a general decline in plant vigour.
Any other aspects of the environment	A — Aphids introduced into a new environment will compete for resources with the native species. They are estimated to have consequences, which are unlikely to be discernible at the national level and of minor significance at the local level.

Indirect consequences

Eradication, control etc.	B — Programs to minimise the impact of these aphids on host plants are likely to be costly and include pesticide applications and crop monitoring. Existing control programs may be effective for some hosts (e.g. broad-spectrum pesticide application) but not all hosts (e.g. where specific integrated pest management programs are used).
Domestic trade	C — The presence of these pests in commercial production areas may have a significant effect at the district level because of any resulting interstate trade restrictions on a wide range of commodities including mangoes and citrus. These restrictions can lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	C — The presence of this pest in commercial production areas of a range of commodities including mango may have a significant effect at the district level due to any limitations to access to overseas markets where this pest is absent.
Environment	A — Although additional pesticide applications would be required to control <i>T. odinae</i> on susceptible crops, this is not considered to have significant consequences for the environment.

Unrestricted risk estimate

The unrestricted risk estimate as determined by combining the overall ‘probability of entry, establishment or spread’ with the ‘consequences’ using the risk estimation matrix (Table 6): **Negligible**.

Cocoa tussock moth

The larvae of cocoa tussock moth cause serious damage to the young leaves of cocoa both in nurseries and plantations. Large populations can cause total defoliation, killing or stunting the tree (Sanchez and Laigo, 1968). The larvae also attack fruits, especially mango, rendering them unsuitable for sale (Fasih *et al.*, 1989). In Taiwan it is a major pest of grapevines and roses (CAB International, 2005). The tussock moth [Lepidoptera: Lymantriidae] examined in this pest risk analysis is:

- *Orgyia australis postica* (Walker) – cocoa tussock moth.

Introduction and spread probability

Probability of importation

The likelihood that *O. australis postica* will arrive in Australia with the importation of fresh mango fruit from Taiwan: **Low**.

- Infested fruits drop from the tree prematurely and those left on the tree have damaged skin and pulp, affecting their market value (Gupta and Singh, 1986).
- Damaged fruit is unlikely to be packed for export.
- Detection of infested fruit during post harvest grading, cleaning and packing procedures is likely to reduce the incidence of larvae on the fruit.

- Oviposition is preferentially on the cocoon of the recently emerged adult (Sanchez and Liago, 1968). As pupation occurs on leaves and stems (Sanchez and Liago, 1968), cocoons would not be associated with packed fruit. Consequently eggs are not likely to be associated with the fruit.

Probability of distribution

The likelihood that *O. australis postica* will be distributed to the endangered area as a result of the processing, sale or disposal of mango fruit from Taiwan: **Low**.

- The commodity is likely to be distributed throughout Australia for retail sale. The intended use of the commodity is human consumption, but waste material would be generated (e.g. mango skin, pulp and seed).
- If eggs and larvae were to survive storage and transport, they may enter the environment through discarded mango fruit.
- Larvae require 15-28 days to fully grow and pupate before reproduction can occur.
- Adults only live for 5 days (Cheng *et al.*, 2001).

Probability of entry (importation × distribution)

The likelihood that *O. australis postica* will arrive in Australia as a result of trade in fresh mangoes from Taiwan, and be distributed to the endangered area: **Very low**.

The overall probability of entry is determined by combining the likelihoods of importation and of distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 4).

Probability of establishment

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

- *O. australis postica* is polyphagous (Fasih *et al.*, 1989) and many hosts are present in Australia. Larvae prefer to feed on fruit.
- Mating must occur to facilitate establishment. However females are flightless and cling to the exterior of their cocoons, calling males to them (Sanchez and Laigo, 1968). Adults only live for 5 days (Cheng *et al.*, 2001).
- Oviposition is generally on the cocoon, with up to 60% of eggs producing larvae (Sanchez and Laigo, 1968). Hatching larvae are not likely to be in close proximity to a suitable host.
- Eggs hatch after about 5-6 days, and the resulting male larvae take 15-26 days to become fully grown; the larger, female larvae take 15-28 days (Sanchez and Laigo,

1968). The female and male pupal stages last 4-5 and 6-7 days, respectively (Sanchez and Laigo, 1968).

- Optimum temperatures for egg hatch is 25°C and for larval development 25-30°C (Cheng *et al.*, 2001). Suitable temperatures exist in Australia.

Probability of spread

The likelihood that *O. australis postica* will spread based on a comparative assessment of those factors in the area of origin and in Australia considered pertinent to the expansion of the geographical distribution of the pest: **Moderate**.

- Tropical or subtropical environments of Australia would be suitable for the spread of *O. australis postica* because it is recorded from these environments.
- Subtropical fruit and broadacre host plants are common in the Australian environment.
- Females are flightless and cling to the exterior of their cocoons and call flighted males to them (Sanchez and Laigo, 1968). Oviposition is generally on the cocoon, with up to 60% of eggs producing larvae (Sanchez and Laigo, 1968). Adults only live for 5 days (Cheng *et al.*, 2001). This would limit the dispersal of *O. postica* in to the environment.

Probability of entry, establishment or spread

The overall likelihood that *O. australis postica* will enter Australia as a result of trade in fresh mangoes from Taiwan, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **Very low**.

The probability of entry, establishment or spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Consequences

Consequences (direct and indirect) of *O. australis postica*: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	C — <i>O. australis postica</i> can cause direct harm to a wide range of plant species of horticultural and broadacre agricultural importance (mango, lychee, cocoa, grapevines, soybean, mung bean, pear) and is estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the regional level.
Any other aspects of the environment	A — There are no known consequences of this pest on other aspects of the environment.
Indirect consequences	
Eradication, control etc.	B — A control program would have to be implemented in infested orchards

	to reduce fruit damage and yield losses, thereby increasing production costs. <i>O. australis postica</i> is estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the district level.
Domestic trade	B — The presence of this pest in commercial production areas is likely to have a significant effect at the local level due to any resulting interstate trade restriction on a wide range of commodities.
International trade	C — The presence of this pest in commercial mango production areas is likely to have a significant effect at the district level due to any limitations to access to overseas markets where this pest is absent.
Environment	A — Although additional pesticide applications would be required to control <i>O. australis postica</i> on susceptible crops, this is unlikely to affect the environment.

Unrestricted risk estimate

The unrestricted risk estimate as determined by combining the overall ‘probability of entry, establishment or spread’ with the ‘consequences’ using the risk estimation matrix (Table 6): **Negligible**.

Mango Thrips

Thrips are minute insects with short segmented antennae, rasping and sucking mouthparts, and narrow wings. Both nymphs and adults feeds by puncturing, lacerating and rasping the surface of leaves and other plant parts (Srivastava, 1997).

The thrips [Thysanoptera: Thripidae] examined in this pest risk analysis is:

- *Rhipiphorothrips cruentatus* Hood, 1919 – mango thrips

Introduction and spread potential

Probability of importation

The likelihood that *R. cruentatus* will arrive in Australia with the importation of fresh mangoes from Taiwan: **Moderate**.

- Mango thrips are known to be associated with mango fruit in Taiwan. Injury to the fruit occurs when thrips puncture the tissues during feeding (Lee and Wen, 1982).
- Damaged fruit show discoloration of tissues at the feeding site (Ikisan, 2000). Quality inspection procedures performed in the packhouse are likely to detect fruit with blemishes, bruising or damage to the skin.
- Mango thrips are small (1.2-1.5 mm) and may be inconspicuous on fruit.
- Post harvest grading, cleaning and packing procedures are likely to reduce the incidence of mango thrips on the fruit.
- Adult females can live for up to 20 days (Rahman and Bhardwaj, 1937). Thrips on the fruit may survive storage and transportation and still be viable on arrival in

Australia.

Probability of distribution

The likelihood that *R. cruentatus* will be distributed as a result of the processing, sale or disposal of fresh mangoes from Taiwan, to the endangered area: **Moderate**.

- Thrips on fruit may survive storage and transportation; however, adults do not tolerate 4°C for more than 5 hours (Rahman and Bhardwaj, 1937).
- Adult females can live for up to 20 days (Rahman and Bhardwaj, 1937).
- Thrips may remain with the commodity during distribution throughout Australia for wholesale or retail trade. The intended use of the commodity is human consumption, but waste material would be generated
- Thrips may be dispersed by wind, or carried by vectors.

Probability of entry (importation × distribution)

The likelihood that *R. cruentatus* will arrive in Australia as a result of trade in fresh mangoes from Taiwan, and be distributed to the endangered area: **Low**.

The overall probability of entry is determined by combining the likelihoods of importation and of distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Probability of establishment

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

- Mango thrips are polyphagous and host plants are common in Australia (e.g. mango and grapevine).
- Mango thrips have a moderate reproductive rate. On wax apples in Taiwan, females each produced about 13 eggs, and reproduction is continuous (CAB International, 2005; Chiu, 1984). In India there are 5-8 generations annually (Rahman and Bhardwaj, 1937), and the thrips overwinters in the pupal phase.
- Although sexual reproduction is normal for the mango thrips, parthenogenesis is also possible (CAB International, 2005).
- The warmer regions of Australia would be suitable for the survival and reproduction of mango thrips. Mango thrips is able to survive exposure to cold temperatures, but only for a short period of time (Rahman and Bhadrwaj, 1937).
- Existing control programs may be effective for some hosts, but not all (e.g. where specific integrated pest management programs are used).

Probability of spread

The likelihood that *R. cruentatus* will spread based on a comparative assessment of those factors in the area of origin and in Australia considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- The polyphagous nature of these thrips should enable them to locate suitable hosts in the intervening areas between production areas.
- Thrips have limited independent dispersal capabilities and are more likely to disperse in association with host plant material. Movement of commodities may aid in the dispersal of thrips. Adults and immature forms may spread undetected via the movement of fruit or infested vegetative host material.
- Environmental conditions (eg temperature, rainfall) similar to those in Taiwan occur in parts of Australia where suitable hosts are found.
- Existing control programs may be effective for some host, but not all (e.g. where specific integrated pest management programs are used).

Probability of entry, establishment or spread

The overall likelihood that *R. cruentatus* will enter Australia as a result of trade in fresh mangoes from Taiwan, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **Low**.

The probability of entry, establishment or spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Consequences

Consequences (direct and indirect) of *R. cruentatus*: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	C — <i>R. cruentatus</i> causes direct harm to a range of host plants including mango and grapevine by puncturing and sucking the sap from the epidermis of leaves and fruit. Affected areas turn dark, leaves curl and drop. In extreme cases, there may be complete defoliation of the host plant. Feeding wounds also serve as sources of entry for fungal attack (Lee and Wen, 1982). Mango thrips are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the regional level.
Any other aspects of the environment	A — Introduced into a new environment <i>R. cruentatus</i> will compete for resources with native species. They are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the local level.
Indirect consequences	
Eradication, control etc.	B — Additional programs to minimise the impact of this pest on host plants may be necessary. Existing control programs can be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g.

Domestic trade	where specific integrated pest management programs are used). B — The presence of these pests in commercial production areas may have a significant effect at the local level because of any resulting interstate trade restrictions on a range of commodities. These restrictions can lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	C — The presence of this pest in commercial production areas of commodities such as mango and grapevine could have a significant effect at the district level because of any limitations to access to overseas markets where this pest is absent.
Environment	A — Although additional pesticide applications would be required to control this pest on susceptible crops, this is not considered to have significant consequences for the environment.

Unrestricted risk estimate

The unrestricted risk estimate as determined by combining the overall ‘probability of entry, establishment or spread’ with the ‘consequences’ using the risk estimation matrix (Table 6): **Very low**.

Pathogen

Mango scab

Mango scab has only been recorded as infecting mango. The fungus is spread by rain splash and requires wet weather to produce new infections. Spores of the asexual stage cause the majority of new infections. Disease symptoms are extremely diverse and vary with the host condition and availability of free water. Mango scab causes little economic damage if effectively controlled with chemicals. The mango scab [Dothideales: Elsinoaceae] examined in this pest risk analysis is:

- **Elsinoë mangiferae* Bitancourt & Jenkins Hood – mango scab

*This species is a quarantine pest for the State of Western Australia.

Introduction and spread potential

Probability of importation

The likelihood that *E. mangiferae* will arrive in Western Australia with the importation of fresh mango fruit from Taiwan: **Low**.

- The conidia of *E. mangiferae* can only infect young tissue of the leaves, stem, flower, fruit stalk and young fruit. Fruit is no longer susceptible after it reaches about half size.
- Heavily affected fruit falls off the tree prematurely (CAB International, 2005).
- Due to the visible symptoms of the disease on any mature fruit remaining on the

tree, most infected fruit will be discarded during sorting, although some fruit with minor symptoms may not be observed and may be exported.

- The pathogen is likely to survive storage and transport. Partially developed infection may progress to visible lesions ranging from small black spots to small or large scarred areas during storage and transport (CAB International, 2005).

Probability of distribution

The likelihood that *E. mangiferae* will be distributed as a result of the processing, sale or disposal of mango fruit from Taiwan, to the endangered area: **Moderate**.

- The pathogen is likely to survive storage and transport. Partially developed infection may progress to visible lesions ranging from small black spots to small or large scarred areas during storage, transport or during distribution (CAB International, 2005).
- The intended use of the commodity is human consumption, but waste material would be generated.
- This species is a quarantine pest for the State of Western Australia due to its absence from this State, but imported mangoes will be distributed throughout Australia.

Probability of entry (importation × distribution)

The likelihood that *E. mangiferae* will enter Western Australia as a result of trade in fresh mangoes from Taiwan, and be distributed in a viable state to the endangered area: **Low**.

The overall probability of entry is determined by combining the likelihoods of importation and of distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 4).

Probability of establishment

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

- The host range of *E. mangiferae* is limited to mango.
- Conducive conditions for the establishment of *E. mangiferae* may occur in some production areas in Australia during the growing season. *E. mangiferae* was recorded in Australia (in Northern Territory and Queensland). Active lesions, characterised by pale brown growth of the conidiophores and conidia, have only been found during wet weather (CAB International, 2005).
- Mango imports would generally be counter-seasonal to Australian mango

production. However the disease preferentially infects young plant material rather than mature fruit (CAB International, 2005).

- The skin of infected fruit may be discarded into environments containing the host. Therefore, the pathogen may survive and infect a mango host nearby, especially in the warmer subtropical and tropical regions of Western Australia where mangoes are grown.

Probability of spread

The likelihood that *E. mangiferae* will spread based on a comparative assessment of those factors in the area of origin and in Australia considered pertinent to the expansion of the geographical distribution of the pest: **Moderate**.

- Arid tropical or subtropical environments of Western Australia would be suitable for the spread of *E. mangiferae* if mango hosts were available.
- The pathogen requires rain splash and periods of free water to produce conidia and for the germination of these conidia to produce new infections.
- Sexual stages of the fungus (ascospores) were only rarely found and asexual conidia were responsible for the bulk of infections (CAB International, 2005).

Probability of entry, establishment or spread

The overall likelihood that *E. mangiferae* will enter Western Australia as a result of trade in fresh mangoes from Taiwan, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Low**

The probability of entry, establishment or spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 4).

Consequences

Consequences (direct and indirect) of mango scab: **Low**.

Criterion	Estimate
<i>Direct consequences</i>	
Plant life or health	C — <i>E. mangiferae</i> is likely to cause significant direct harm to mango production at the district level. Without chemical control, losses as high as 90% have been observed in one mango orchard during an investigation in 1996–97 in Darwin, Australia (B.D. Condé, NT Department of Primary Industry and Fisheries, Darwin, Australia, unpublished data) (CAB International, 2005)
Any other aspects of the environment	A — <i>E. mangiferae</i> only affects mango. There are no known direct consequences of this pest on the natural or built environment.
<i>Indirect consequences</i>	

Eradication, control etc.	B — Programs to minimise the impact of this disease on host plants are likely to be required and are likely to incur costs for fungicide sprays and additional crop monitoring.
Domestic trade	B — The presence of this disease in commercial production areas may have a significant effect at the local level because of any resulting interstate trade restrictions on mangoes within Western Australia.
International trade	B — The presence of this disease in commercial production areas of mango may have a significant effect at the local level because of any limitations to access to overseas markets where this pest is absent.
Environment	A — Although additional fungicide applications would be required to control this disease on mango, this is unlikely to affect the environment.

Unrestricted risk estimate

The unrestricted risk estimate as determined by combining the overall ‘probability of entry, establishment or spread’ with the ‘consequences’ using the risk estimation matrix (Table 6): **Very low**.

Table 8 Summary of pest risk assessments and unrestricted risk estimates

Pest name	Probability of					Overall probability of entry, of establishment and of spread	Consequences	Unrestricted Risk
	Entry			Establishment	Spread			
	Importation	Distribution	Overall probability of entry					
ARTHROPODS (no.)								
Fruit flies (4)	High	High	High	High	High	High	High	High
Armoured scales (5)	High	Moderate	Moderate	High	Moderate	Low	Low	Very low
Soft scales (2)	High	Moderate	Moderate	High	Moderate	Low	Low	Very low
Mealybugs (4)	High	Moderate	Moderate	High	High	Moderate	Low	Low
Mango aphid (1)	Low	Low	Very low	High	High	Very low	Low	Negligible
Cocoa tussock moth (1)	Low	Low	Very low	Moderate	Moderate	Very low	Low	Negligible
Mango thrips (1)	Moderate	Moderate	Low	High	High	Low	Low	Very low
PATHOGEN								
Mango scab	Low	Moderate	Low	Moderate	Moderate	Low	Low	Very low

Risk assessment conclusion

Table 8 summarises the detailed risk assessments and provides unrestricted risk estimates for the quarantine pests considered to be associated with mangoes from Taiwan.

Fruit flies and mealybugs were assessed to have unrestricted risk estimates of ‘high’ and ‘low’ respectively. These pests are above Australia’s ALOP. Phytosanitary risk management measures are therefore required. The remaining pests were assessed to have an unrestricted risk of ‘very low’ and therefore they do not require the application of any specific phytosanitary measures in order to meet Australia’s ALOP.

Table 9 provides the final list of quarantine pest of mangoes from Taiwan that require the use of phytosanitary risk management measures in addition to the standard practices used in the production of commercial mangoes in Taiwan to meet Australia’s ALOP. The proposed risk management measures are described in the following section.

Table 9: Quarantine pests of mangoes from Taiwan assessed to have an unrestricted risk estimate that does not meet Australia’s ALOP and requires risk management measures

Pest	Common name
ARTHROPODS	
<i>Bactrocera cucurbitae</i> (Coquillett, 1899) [Diptera: Tephritidae]	melon fruit fly
<i>Bactrocera dorsalis</i> (Hendel, 1912) [Diptera: Tephritidae]	Oriental fruit fly
<i>Bactrocera latifrons</i> (Hendel, 1915) [Diptera: Tephritidae]	solanum fruit fly
<i>Bactrocera tau</i> (Walker) [Diptera: Tephritidae]	fruit fly
<i>Planococcus lilacinus</i> (Cockerell, 1905)[Hemiptera: Pseudococcidae]	coffee mealybug
<i>Pseudococcus cryptus</i> Hempel [Hemiptera: Pseudococcidae]	citriculus mealybug
<i>Pseudococcus jackbeardsleyi</i> Gimpel & Miller [Hemiptera: Pseudococcidae]	Jack Beardsley mealybug
<i>Rastrococcus spinosus</i> (Robinson, 1918) [Hemiptera: Pseudococcidae]	Philippine mango mealybug

Stage 3: Pest Risk Management

Pest risk management evaluates and selects measures to reduce the risk of entry, establishment or spread of quarantine pests with an unrestricted risk estimate that does not meet Australia’s ALOP. In this case, risks are due to the importation of commercially produced mangoes from Taiwan, i.e. fruit from commercial production sites and subjected to standard cultivation, harvesting and packing activities.

Unrestricted risk estimates should take into account only the minimum border procedures used by relevant government agencies and not measures intended to mitigate risks

associated with the commodity itself. The minimum procedures include verifying that the commodity is as described in the shipping documents and identifying external and internal contamination of containers and packaging.

Risk management measures and operational systems

Biosecurity Australia considers that the risk management measures recommended in this report, implemented in conjunction with the operational system for the maintenance and verification of the phytosanitary status of mangoes from Taiwan, will provide an appropriate level of protection against the pests identified in the risk assessment.

The following risk management measures and phytosanitary procedures are recommended to mitigate the risks identified in the PRA:

- pre-export vapour heat treatment (VHT) for the management of fruit fly species;
- inspection and remedial action for mealybugs; and
- supporting operational systems to maintain and verify phytosanitary status.

The measures described in detail below will form the basis of the import conditions for fresh mangoes from Taiwan.

Biosecurity Australia does, however, recognise that other risk management measures may be suitable to manage the risks associated with mangoes from Taiwan and it will consider any other measures that would provide an equivalent level of protection.

[1] Pre-export disinfestation for the management of fruit fly species

Fruit flies, *Bactrocera cucurbitae* (melon fly), *B. dorsalis* (Oriental fruit fly), *B. latifrons* (solanum fruit fly) and *B. tau* have been assessed to have an unrestricted risk estimate of 'high' for mangoes from Taiwan and therefore require measures to mitigate that risk.

Visual inspection alone is not considered to be an appropriate risk management option in view of the level of risk identified and because clear visual signs of infestation (particularly in recently infested fruit) may not be present. If infested fruit was not detected at inspection, fruit flies might enter, establish and spread in Australia.

Measures that might be applied to mitigate risks associated with fruit flies are either, the sourcing of fruit from pest free areas or the use of disinfestation treatments such as heat treatments (vapour heat or hot water immersion), chemical treatment or irradiation. All these measures were identified as in-principle options for fruit flies. However, some options were considered no more effective and possibly less technically, economically and environmentally feasible than that proposed by Taiwan.

Taiwan has identified vapour heat treatment as their preferred treatment option against fruit flies for export of mangoes to Australia. Taiwan treats mango fruit with vapour heat for current export of mangoes from Taiwan to Japan and New Zealand.

Biosecurity Australia has identified alternative measures to VHT which Taiwan may consider for the disinfestation of fruit flies. These are hot water immersion and irradiation.

[1a] Vapour heat treatment (VHT)

Vapour heat treatment is used as an effective disinfestation treatment for certain fruit fly species in certain fruit in international trade.

In 2003, Taiwan proposed the use of VHT for the disinfestation of fruit flies. BAPHIQ provided a report 'Vapour Heat Treatment for Elimination of *Dacus dorsalis* and *Dacus cucurbitae* Infested in Mango Fruits var. Haden' (Ku *et al.*, 1989) on the efficacy of using VHT for the disinfestation of fruit flies. Eggs and larvae of *Bactrocera dorsalis* (the most heat tolerant species) and *B. cucurbitae* were killed when the mango fruit pulp temperature was maintained at 46.5°C for 30 minutes.

Biosecurity Australia accepts the use of VHT to mitigate the risk of fruit fly species of quarantine concern associated with imported mango fruit from Guimaras Island (Philippines) under a treatment regime of 46.0°C (fruit pulp temperature) for 10 minutes.

It has therefore been demonstrated that VHT proposed by Taiwan (Ku *et al.*, 1989) adequately mitigates the risk posed by fruit fly species of quarantine concern associated with mango fruit from Taiwan to a level that meets Australia's ALOP.

Biosecurity Australia proposes the option of a pre-export VHT of 46.5°C (fruit pulp temperature) for 30 minutes for all mango cultivars from Taiwan. The total treatment time would be for a minimum time of two hours, including both the warming and cooling periods to bring the fruit pulp to the target temperature. Treatment would commence when the fruit pulp temperature of all monitored fruit reaches, or is above, the required temperature (46.5°C) and this temperature is maintained for the required period (30 minutes).

All registered treatment facilities would be inspected and audited by Biosecurity Australia and AQIS before the first export season to treat mangoes for export to Australia. Subsequently, registered treatment facilities would be annually inspected and audited by BAPHIQ and AQIS would audit as required. Details of the treatment and temperature values would be recorded and monitored by BAPHIQ.

The quarantine security of the product would be maintained after the VHT to prevent reinfestation by fruit flies during storage, movement and shipping of the treated fruit. Phytosanitary inspection of the treated fruit would be conducted by BAPHIQ and the details of the treatment included on the Phytosanitary Certificate (see measure 3f).

[1b] Hot water immersion

Hot water is used as an effective disinfestation treatment for certain fruit fly species in certain fruit in international trade. Treatment schedules are usually specific to particular combinations of pest species and commodity. For example, the USDA uses treatment schedule *T102 – a Hot water dip against Mediterranean fruit fly and Mexican fruit fly in mangoes* at a temperature of 115°F (46.1°C) for 65–110 minutes depending upon the size (375-900 g) and shape (flat, elongated vs rounded cultivars) of fruit (USDA, 2005). The literature indicates that the efficacy of the treatment depends on the size and shape of the mango fruit. Biosecurity Australia accepts this treatment against these fruit flies for mangoes imported from Mexico. Biosecurity Australia would consider efficacy data for hot water immersion against the quarantine *Bactrocera* species on mangoes in Taiwan.

[1c] Irradiation

The International Plant Protection Convention acknowledges the application of ionising irradiation as a phytosanitary treatment for regulated pests or articles in *ISPM No. 18: Guidelines for the use of irradiation as a phytosanitary measure* (FAO, 2003).

Australia accepts irradiation as an effective phytosanitary measure to alleviate certain arthropod pest infestation in selected tropical fruits for trade between Australia and other countries. Irradiation to a maximum of 1 kGy (kiloGray) is permitted as a phytosanitary measure for use on breadfruit, carambola, custard apple, litchi, longan, mango, mangosteen, papaya and rambutan by Food Standards Australia New Zealand (FSANZ). See:

<http://www.foodstandards.gov.au/mediareleasespublications/factsheets/factsheets2003/irradiationoftropical1944.cfm>.

Australia currently exports fresh mangoes to New Zealand using irradiation treatment against fruit flies and other pests.

Taiwan advised Biosecurity Australia in 2003 that they would not consider irradiation as a phytosanitary measure for imports or exports of fresh produce at that time.

[2] Inspection and remedial action for mealybugs

Mealybugs *Pseudococcus cryptus* (citriculus mealybug), *P. jackbeardsleyi* (Jack Beardsley mealybug), *Planococcus lilacinus* (coffee mealybug) and *Rastrococcus spinosus* (Philippine mango mealybug) were assessed as having an unrestricted risk estimate of 'low', therefore measures are required to mitigate that risk.

Biosecurity Australia considers that, for the fruit sourced from registered export orchard growers, consignment freedom from mealybugs can be verified by targeted visual inspection pre-export and on-arrival in view of the level of risk identified and given trained

inspectors can readily detect these pests. Mango fruit would be inspected for the presence of the mealybugs. Visual inspection would involve the examination of a 600-unit sample of mango fruit to detect the presence of mealybugs during pre-export inspection in Taiwan (3e) and on-arrival clearance in Australia (3g). Pre-export inspection is to be completed after heat treatment (VHT).

Remedial action when pests are detected is required as the risk management option for these pests. If infested fruit was not inspected and detected, these pests might enter, establish and spread in Australia. The objective of this measure is to ensure that consignments of mangoes from Taiwan infested with these pests can be identified and subjected to remedial action. Biosecurity Australia considers that this measure is appropriate to mitigate the risk associated with mealybugs to ‘very low’, which meets Australia’s ALOP.

[3] Operational systems for the maintenance and verification of phytosanitary status

It is necessary to have a system of operational procedures in place to ensure that the phytosanitary status of mangoes from Taiwan is maintained and verified during the process of production and export to Australia. This is to ensure that the objectives of the risk mitigation measures previously identified have been met and are being maintained.

Biosecurity Australia recommends a system for that purpose which is equivalent to the system currently in place for the importation of fresh mangoes from Guimaras Island, the Philippines. This is to ensure that requirements are appropriate to the circumstances of Taiwan for mango production and export.

The recommended system of operational procedures for the production and export of fresh mangoes to Australia from Taiwan consists of:

- registration of export orchards;
- registration of packhouses and auditing of procedures;
- packaging and labelling;
- specific conditions for storage and movement of treated produce;
- on-arrival phytosanitary inspection and remedial action, and clearance by AQIS;
- phytosanitary certification by BAPHIQ; and
- pre-export phytosanitary inspection and remedial action by BAPHIQ.

[3a] Registration of export orchards

All mango fruit for export to Australia must be sourced from export orchards and growers registered with BAPHIQ. Copies of the registration records must be made available to

AQIS if requested. The BAPHIQ is required to register all export orchards before exports commence.

The hygiene of export orchards must be maintained by appropriate pest management options that have been approved by BAPHIQ, to manage pest and diseases of quarantine concern to Australia. Registered growers must keep records of control measures for auditing purposes. Information on BAPHIQ-approved orchard control program and audit records must be made available to AQIS if requested.

The objective of this procedure is to ensure that orchards from which mangoes are sourced can be identified. This is to allow trace-back to individual orchards and growers in the event of non-compliance. For example, if live pests are intercepted, the ability to identify a specific orchard/grower allows the investigation and corrective action to be targeted rather than applying to all contributing orchards.

[3b] Registration of packhouses and auditing of procedures

All packhouses intending to export mango fruit to Australia need to be registered with BAPHIQ for trace-back purposes.

Vapour heat treatment (VHT) for pre-export disinfestation of fruit flies is to be performed within the registered packhouses/treatment facilities in Taiwan. AQIS will only approve designated and identified VHT facilities that are registered by BAPHIQ.

The targeted inspection for freedom from fruit fly and mealybugs is to be carried out within the registered packhouses following VHT.

Packhouses are required to identify the individual orchard with a numbering system and identify fruit from individual orchards by marking boxes or pallets (i.e. one orchard per pallet) with the unique orchard number. The list of registered packhouses must be kept by BAPHIQ before the export season commences, with any updates provided when packhouses are added or removed from the list. Packhouse registration records must be made available to AQIS if required.

Registration of packhouses and treatment facilities in the initial export season is to include an audit program conducted by AQIS of the packhouses and treatment facilities before exports commence. After the initial approval of the registered packhouses and treatment facilities, AQIS will require BAPHIQ to audit the facilities at the beginning of each season to ensure that packhouses are suitably equipped to carry out the specified phytosanitary tasks and treatments. Records of annual BAPHIQ audits must be available to AQIS on request.

The objective of this procedure is to ensure that packhouses at which the VHT and inspections are conducted can be identified. This is to allow trace-back to individual packhouses and orchards/growers in the event of non-compliance.

[3c] Packing and labelling

All packages of mangoes for export to Australia are to be free from all regulated articles¹. (e.g. trash) and pests of quarantine concern to Australia, and must also meet Australia's general import conditions for fresh fruits and vegetables (*C6000 General Requirements for all fruit and vegetables*, available at <http://www.aqis.gov.au/icon/>).

Treated and inspected fruit is required to be packed in new boxes. The fruit must be packed in boxes that have had any openings either screened with mesh or covered with tape. Alternatively, the non insect-proof boxes can be made insect proof by palletising and shrink wrapping with polythene/plastic/foil or mesh cloth prior to leaving the secure packing area. Packing material is to be synthetic or highly processed if of plant origin. No unprocessed packing material of plant origin, such as straw, will be allowed. All wood material used in packaging of mango fruit must comply with the AQIS conditions (e.g. those in '*Cargo containers: Quarantine aspects and procedures*' (AQIS, 2005)).

All boxes should be labelled with the orchard registration number, packhouse registration number and treatment facility number for the purposes of trace-back in the event that this is necessary. Where boxes are palletised, the pallets are to be securely strapped only after phytosanitary inspection has been carried out following mandatory post-harvest treatments. Palletised product is to be identified by attaching a uniquely numbered pallet card (containing the information that would be included on the boxes) to each pallet or part pallet to enable trace back to registered orchards.

The objectives of this procedure are to ensure that:

- the mango fruit exported to Australia is not contaminated by quarantine pests or regulated articles;
- unprocessed packing material (which may vector pests identified as not on the pathway and pests not known to be associated with mangoes) is not imported with the mangoes; and
- the packaged mango fruit are labelled in such a way to identify the orchard and packhouse and treatment facility (see measures 3a,b).

[3d] Specific conditions for storage and movement

Packed product and packaging is to be protected from pest contamination during and after packing, after treatment, after inspection, during storage, during movement between

¹ The IPPC defines regulated article as "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".

locations (e.g. packhouse to cool storage/depot, to inspection point, to export point) and shipping.

Product for export to Australia that has been treated, inspected and certified by BAPHIQ must be maintained in a secure manner to prevent mixing with fruit for export to other destinations, in order for the quarantine integrity of the fruit to be maintained.

The objective of this procedure is to ensure that the phytosanitary status of the product is maintained during storage, movement and shipping.

[3e] Pre-export phytosanitary inspection and remedial action by BAPHIQ

BAPHIQ will inspect all consignments in accordance with AQIS standard protocol for all visually detectable quarantine pests and other regulated articles (e.g. trash). The AQIS sampling protocol requires inspection of 600 units (mango fruit) for quarantine pests, in systematically selected random samples per homogeneous consignment² or lot³.

Biometrically, if no pests are detected by the inspection, this sample size achieves a confidence level of 95% that not more than 0.5% of the units in the consignment are infested/infected. The level of confidence depends on each fruit in the consignment having about the same likelihood of being affected by a quarantine pest and the inspection technique being able to reliably detect all quarantine pests in the sample. For mangoes, AQIS defines a unit as a single mango fruit.

The detection of quarantine pests or regulated articles during an inspection will result in the failure of the inspection lot. Remedial action may then be taken. Action may include:

- withdrawing the consignment from export to Australia; or
- treatment and re-inspection of the consignment to ensure that the pest is no longer viable.

If live fruit flies are detected in the consignments, the treatment facility must be suspended until AQIS/Biosecurity Australia and BAPHIQ are satisfied that appropriate corrective action has been taken.

Records of interceptions made during these inspections (live or dead quarantine pests, and regulated articles) are to be maintained by BAPHIQ and made available to Biosecurity Australia if requested. This information will assist in future reviews of this import pathway

² A consignment is the number of boxes of mango fruit from shipment from Taiwan to Australia covered by one phytosanitary certificate.

³ An inspection lot is the number of boxes presented for a single phytosanitary inspection.

and consideration of the appropriateness of the phytosanitary measures that have been applied.

The objective of this procedure is to verify the effectiveness of orchard and packhouse controls and to ensure that mango fruit exported to Australia do not contain quarantine pests or regulated articles, and comply with packing and labelling requirements.

[3f] Phytosanitary certification by BAPHIQ

BAPHIQ will issue an International Phytosanitary Certificate (IPC) for each consignment upon completion of pre-export treatment and phytosanitary inspection. The objective of this procedure is to provide formal documentation to AQIS verifying that the relevant measures have been undertaken offshore.

Each IPC is to contain the following information that is consistent with *ISPM No. 7 Export Certification Systems* (FAO, 1997):

Additional declarations

“The mangoes in this consignment have been produced in Taiwan in accordance with the conditions governing entry of fresh mangoes to Australia and inspected and found to be free of quarantine pests”.

Distinguishing marks

The orchard registration number, packhouse registration number/treatment centre registration number, number of boxes per consignment, and container and seal numbers (as appropriate); to ensure trace-back to the orchard in the event that this is necessary.

Treatments

Details of VHT (i.e. fruit pulp temperature, duration and packhouse/treatment facility number, date) must be included in the treatment section on the IPC.

A consignment is the quantity of mango fruit covered by one IPC that arrives at one port in one shipment. Consignments need to be shipped directly from one port or city in Taiwan to a designated port or city in Australia or transhipped in sealed containers.

[3g] On-arrival phytosanitary inspection and remedial action, and clearance by AQIS

On arrival in Australia, each consignment will be inspected by AQIS. AQIS would undertake a documentation compliance examination for consignment verification purposes

at the first port of entry in Australia before inspection, clearance and release from quarantine.

The standard AQIS inspection protocol will apply. Fruit from each consignment would be randomly sampled for inspection. The sampling methodology provides 95% confidence that there is not more than 0.5% infestation in a consignment. No land bridging of goods will be permitted unless goods have cleared quarantine. The detection of quarantine pests and/or regulated articles will result in the failure of the inspection lot.

The objective of this procedure is to verify that the required measures have been adequately undertaken in the exporting country.

[4] Action for non-complying lots

Where inspection lots are found to be non-compliant with import requirements at AQIS on-arrival inspection because of the presence of quarantine pests or other regulated articles, remedial action must be taken. Action may include:

- re-export of the consignment from Australia; or
- destruction of the consignment; or
- treatment (where an appropriate treatment is available) and re-inspection of the consignment to ensure that the pest is no longer viable.

Methyl bromide is commonly used by AQIS as a remedial action against certain external feeding arthropod pests detected during on-arrival inspection and applied at a rate determined by AQIS depending upon the pests detected.

If live fruit flies are detected in the consignments, the treatment facility will be suspended until AQIS/Biosecurity Australia and BAPHIQ are satisfied that appropriate corrective action has been taken.

If product continually fails to comply with the import requirements, Biosecurity Australia and/or AQIS reserve the right to suspend the mango exports from Taiwan and conduct an audit of the mango export management systems in Taiwan. The program will recommence only after Biosecurity Australia and/or AQIS are satisfied that appropriate corrective action has been taken.

[5] Uncategorized pests

If an organism that is detected on mangoes from Taiwan has not been categorised, it will require assessment to determine its quarantine status and whether phytosanitary action is required. The detection of any significant pests of quarantine concern not already identified in the analysis may result in the suspension of the trade while a review is conducted to ensure that the existing measures continue to provide the appropriate level of phytosanitary protection for Australia.

DRAFT IMPORT CONDITIONS

The components of the final revised import conditions are summarised in dot point format below. The recommended risk management measure that links with each component is given in parentheses.

Biosecurity Australia considers that the risk management measures and operational systems identified in the previous section, upon which these import conditions are based, are commensurate with the identified risks. Note that Biosecurity Australia regards the import conditions listed below to be consistent with, and equivalent to, those currently in place for the importation of fresh mangoes from the Philippines (Guimaras Island).

- Registration of export orchards (3a);
- Registration of packhouses and auditing of procedures (3b);
- Pre-export vapour heat treatment for fruit flies (1a);
- Packing and labelling (3c);
- Storage and movement (3d);
- Targeted pre-export inspection and remedial action by BAPHIQ (2, 3a, 3e);
- Phytosanitary certification by BAPHIQ (3f);
- Targeted on-arrival quarantine inspection and remedial action, and clearance by AQIS (2, 3a, 3b, 3g, 4);
- Uncategorised pests (5);
- Audit of protocol; and
- Review of policy.

1 Registration of export orchards

All mango fruit for export to Australia must be sourced from export orchards and growers registered with BAPHIQ before the commencement of the export season. BAPHIQ must register all export orchards and maintain a list of registered orchards. Copies of the registration records must be made available to AQIS if requested. Registration by BAPHIQ is required to enable trace-back in the event of non-conformity.

All export orchards must produce commercial mango fruit under standard cultivation, harvesting and packing activities. Registered export orchard growers must implement an orchard control program (i.e. good agricultural practices and/ IPM programs for export fruit) that has been approved by BAPHIQ, incorporating field sanitation and appropriate biocontrol and/or pesticide applications for the management of quarantine pests of concern to Australia.

Registration of export orchards is to include an audit program conducted by BAPHIQ to ensure that a BAPHIQ-approved orchard control program has been implemented. An audit is to be conducted for registration and then conducted annually.

2 Registration of packhouses and auditing of procedures

All packhouses intending to export mango fruit to Australia must be registered with BAPHIQ before the commencement of the export season. A list of all registered packhouses must be maintained by BAPHIQ and made available to AQIS on request.

The targeted inspection for freedom from quarantine pests and regulated articles is to be carried out within the registered packhouses.

Packhouses will be required to identify the individual orchard with a numbering system and identify fruit from individual orchards by marking boxes or pallets (i.e. one orchard per pallet) with the unique orchard number.

BAPHIQ must ensure that fruit destined for Australia is not mixed with fruit for other destinations. The identity and origin of the fruit for export must be maintained throughout the packing process.

Registration of packhouses is to include an audit program conducted by BAPHIQ to ensure that packhouses are suitably equipped to provide security of fruit against reinfestation/reinfection. An audit is to be conducted before registration and then conducted annually by BAPHIQ. Records of annual audits must be made available to AQIS if requested.

If any new pest of potential quarantine concern to Australia is detected, BAPHIQ must notify Biosecurity Australia/AQIS immediately to ensure appropriate action is taken.

3 Pre-export vapour heat treatment (VHT)

The export fruit must undergo vapour heat treatment for fruit fly disinfestation prior to export.

Vapour heat treatment for pre-export disinfestation for fruit flies is to be conducted within the registered packhouses and VHT facilities registered with, and audited by, BAPHIQ to ensure they are suitably equipped to carry out the specified VHT.

All treatment facilities must have heat treatment equipment capable of achieving and holding the required fruit pulp temperatures. Treatment facilities must keep records of temperature and humidity values of all fruit lot treatments for audit purposes by BAPHIQ and AQIS.

AQIS will only approve designated and identified VHT facilities that are registered by BAPHIQ.

Registered facilities must be initially inspected and audited by quarantine officials from Biosecurity Australia and/or AQIS before the commencement of treatment of mango fruit for export to Australia.

Facilities must be designed to prevent the entry of fruit flies into areas where unpacked and packed treated fruit is held and include a provision for treated fruit to be discharged directly into insect-proof and secure packing rooms. The management of the treatment facility will be required to provide details of the systems in place to ensure isolation and segregation from other fruit throughout the treatment, packing, storage and transport stages before exports commence. These details would be audited for compliance with AQIS requirements in the initial export season.

Subsequently, any additional un-registered treatment facilities must be inspected and audited by quarantine officials from Biosecurity Australia and/or AQIS before they commence treating mango fruit for export to Australia. All costs associated with Biosecurity Australia and/or AQIS audits or inspections would be paid for by Taiwan.

AQIS would require BAPHIQ to audit the treatment facilities at the beginning of each season to ensure that they comply with AQIS requirements before registration is renewed. BAPHIQ is to monitor the treatment facilities throughout their operational season to ensure continued compliance with AQIS requirements. Reports of BAPHIQ audits noting any non-conformity together with appropriate corrective action would be submitted to AQIS if requested.

BAPHIQ officers would ensure the following:

- registered treatment facilities are maintained in a condition that will provide efficacy in treatment programs;
- all areas are hygienically maintained (cleaned daily of damaged, blemished, infested fruit);
- premises are maintained to exclude the entry of pests from outside and between treated and untreated fruit;
- all measurement instruments are regularly calibrated and records are retained for verification;
- records kept of the movements of fruit from the time of arrival at the registered treatment centre through to the time of export; and
- security of fruit is maintained at all times when fruit is on the premises.

BAPHIQ must monitor all heat treatments. Mango fruit must be treated at or above 46.5°C (fruit pulp temperature) for a minimum of 30 minutes in accordance with the following schedule:

- Treatment time will be for a minimum of two hours, including the warming and cooling periods to bring the fruit pulp to the required temperature (46.5°C).
- Treatment commences when the fruit pulp temperature of all probe-monitored fruit reaches, or is above, the required temperature. This temperature must be maintained for the required period (30 minutes).

Details of the treatment and temperature values must be recorded and monitored by BAPHIQ and forwarded to AQIS as an attachment to the Phytosanitary Certificate.

The phytosanitary security of the product must be maintained after the VHT to prevent reinfestation by fruit flies or any other external pests. Phytosanitary inspection of the treated fruit must be conducted by BAPHIQ and the details of the treatment included on the Phytosanitary Certificate.

4 Packing and labelling

All packages of mangoes for export must be free from regulated articles and must meet Australia's general import conditions for fresh fruits and vegetables (*C6000 General requirements for all fruit and vegetables*, available at <http://www.aqis.gov.au/icon/>).

Treated and inspected fruit for export to Australia will be required to be packed in new boxes. Packing material must be synthetic or highly processed if of plant origin. No unprocessed packing material of plant origin, such as straw, will be allowed. All wood material used in packaging of mango fruit must comply with the AQIS conditions (e.g. those in '*Cargo containers: Quarantine aspects and procedures*' (AQIS, 2005)).

All boxes will be labelled with the orchard registration number and packhouse/treatment facility registration number for the purposes of trace-back if that is necessary. If boxes are palletised, the pallets should be securely strapped only after phytosanitary inspection has been carried out following mandatory post-harvest treatments. Palletised product is to be identified by attaching a uniquely numbered pallet card to each pallet or part pallet to enable trace-back to registered orchards, packhouses and treatment facilities.

5 Storage and movement

Product, and its packaging, are to be protected from pest contamination during and after treatment packing, during storage and during movement between locations (that is, from packhouse to cool storage/depot, to inspection point, to export point) and shipping.

Product for export to Australia that has been inspected and certified by the BAPHIQ must be maintained in secure conditions that will prevent mixing with fruit for export to other destinations using one of the following methods:

- packed fruit can be directly transferred at the packhouse into a shipping container, which is to be sealed and not opened until the container reaches Australia; or
- fruit packed into boxes installed with screened ventilation holes; the screening mesh size not to exceed 1.6 mm and not less than 0.16 mm strand thickness; or
- segregation of fruit for export to Australia in separate storage facilities; or
- packed fruit boxes on pallets shrink-wrapped in plastic or netted; or
- sealed boxes kept in cold storage before loading into a shipping container.

BAPHIQ must ensure that records are properly maintained to facilitate auditing of fruit during or after storage. Security of the consignment is to be maintained until arrival in Australia to protect from pest contamination.

6 Targeted pre-export inspection and remedial action by BAPHIQ

BAPHIQ will inspect all consignments in accordance with AQIS procedures for all visually detectable quarantine pests and regulated articles⁴. The AQIS sampling protocol requires inspection of 600 units for quarantine pests, in systematically selected random samples per homogeneous consignment⁵ or lot⁶. For mangoes, AQIS defines a unit as one mango fruit. Biometrically, if no pests are detected by the inspection, this size sample achieves a confidence level of 95% that not more than 0.5% of the units in the consignment are infested/infected. The level of confidence depends on each fruit in the consignment having about the same likelihood of being affected by a quarantine pest and the inspection technique being able to reliably detect all quarantine pests in the sample.

The detection of quarantine pests or regulated articles during the inspection will result in the failure of the inspection lot. Remedial action may then be taken. Remedial action may include:

- withdrawing the consignment from export to Australia; or
- treatment and re-inspection of the consignment to ensure that the pest is no longer viable.

⁴ The IPPC defines regulated article as “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”.

⁵ A consignment is the number of boxes of mango fruit from shipment from Taiwan to Australia covered by one phytosanitary certificate.

⁶ An inspection lot is the number of boxes presented for a single phytosanitary inspection.

The inspection must be undertaken on packed fruit in boxes that have already undergone the heat treatment, and must be completed in packhouses that are registered with, and audited by, BAPHIQ. Records of interceptions made during these inspections (live or dead quarantine pests and regulated articles) are to be maintained by BAPHIQ and made available to Biosecurity Australia as requested. This information will assist in future reviews of this import pathway and consideration of the appropriateness of the phytosanitary measures that have been applied.

7 Phytosanitary certification by BAPHIQ

BAPHIQ is required to issue an International Phytosanitary Certificate (IPC) for each consignment upon completion of treatment for fruit flies and pre-export inspection. Each IPC is to contain the following information:

Additional declaration

Additional declaration stating:

“The mangoes in this consignment have been produced in Taiwan in accordance with the conditions governing entry of fresh mangoes to Australia and inspected and found to be free of quarantine pests”.

Distinguishing marks

The orchard registration number, packhouse registration number, number of boxes per consignment container and seal numbers (as appropriate), and date; to ensure trace back to the orchard in the event that this is necessary.

A consignment is the quantity of mango fruit covered by one Phytosanitary Certificate that arrives at one port in one shipment. Consignments need to be either shipped directly from one port or city in Taiwan to a designated port or city in Australia, or if transhipped in Taiwan or Australia, containers must remain sealed.

Treatments

Details of vapour heat treatment (i.e. temperature, duration, packhouse/treatment facility number, and date of treatment) must be included in the treatment section on the Phytosanitary Certificate.

8 Targeted on-arrival quarantine inspection and remedial action, and clearance by AQIS

On arrival, AQIS will undertake a documentation compliance examination for consignment verification purposes at the port of entry in Australia prior to inspection and release from quarantine. Any 'consignment' with incomplete/inadequate documentation, or where certification does not conform to specifications, or seals on the containers are damaged or missing, will be held pending clarification by BAPHIQ and determination by AQIS, with the options of re-export or destruction. BAPHIQ will be notified by AQIS of any such problems.

Consignments will be inspected by AQIS using the standard AQIS inspection protocol. The sampling provides 95% confidence that there is not more than 0.5% infestation in a consignment. The detection of live quarantine pests and/or regulated articles will result in the failure of the inspection lot.

An example of a sample size for inspection of mangoes is given below. The unit is defined as single mango fruit.

Consignment size (Units*)	Sample size (Units)
For consignments of fruit of less than 1000 units	Either 450 units or 100% of consignment (whichever is smaller)
For consignments of fruit of greater than or equal to 1000 units	600 units

* Unit = one mango fruit

If no live quarantine pests are detected in the sample, the consignment is considered to be free from quarantine pests and will be released from quarantine. No land bridging of goods will be permitted unless goods have cleared quarantine.

Remedial action for non-complying lots

Where consignments are found to be non-compliant with import requirements at AQIS on-arrival inspection because of the presence of quarantine pests or other regulated articles, remedial action must be taken. Action may include:

- re-export of the consignment from Australia; or
- destruction of the consignment; or
- treatment (where an appropriate treatment is available) and re-inspection of the consignment to ensure that the pest is no longer viable.

If live fruit flies are detected in the consignments, exports from the relevant treatment facility will be suspended until AQIS/Biosecurity Australia and BAPHIQ are satisfied that appropriate corrective action has been taken.

If product continually fails to comply with the import requirements, Biosecurity Australia and/or AQIS reserves the right to suspend the mango exports from Taiwan and conduct an audit of the mango export management systems in Taiwan. The program will recommence only after Biosecurity Australia and/or AQIS are satisfied that appropriate corrective action has been taken.

Documentation errors

Any consignment with incomplete documentation, or where certification does not conform to specifications, or seals on the containers are damaged or missing, will be held pending further clarification by BAPHIQ and determination by AQIS, with the options of re-export or destruction. BAPHIQ will be notified immediately by AQIS of any such problems.

9 Uncategorized pests

If an organism that is detected on mango from Taiwan has not been categorised, it will require assessment to determine its quarantine status and whether phytosanitary action is required. The detection of any pests of quarantine concern not already identified in the analysis may result in the suspension of the trade while a review is conducted to ensure that the existing measures continue to provide the appropriate level of phytosanitary protection for Australia.

10 Audit of protocol

During the first season of trade, an officer from Biosecurity Australia and/or an officer from AQIS will visit the areas in Taiwan designated for the export of mangoes to Australia to audit the operation of the protocol including registration, operational procedures and VHT facilities.

11 Review of policy

Biosecurity Australia reserves the right to review the adopted policy at any time after significant trade has occurred or when there is reason to believe that the phytosanitary status of the exporting country has changed.

CONCLUSIONS

The findings of this draft extension of policy are based on a comprehensive analysis of relevant available scientific literature and existing import requirements for mangoes from the Philippines.

Biosecurity Australia considers that the risk management measures proposed in the draft extension of policy would provide an appropriate level of protection against the pests identified in the PRA.

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APPENDIX 1: PEST CATEGORISATION FOR MANGOES FROM TAIWAN

* Pests listed in pest risk assessments for the importation of mangoes from the Philippines (AQIS (1999) and India DAFF (2004).

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
ARTHROPODA						
ACARINA						
<i>Cisaberoptus kenyae</i> Keifer Syn: <i>Cisaberoptus kenya</i> Huang [Acarina: Eriophyidae]	Mango leaf mite	Yes	Yes (Lee, 1988; Huang <i>et al.</i> , 1990)	Yes (Knihinicki & Boczek, 2002)		No
<i>Oligonychus mangiferus</i> (Rahman & Sapro, 1940) Syns: <i>Paratetranychus insularis</i> McGregor; <i>Paratetranychus terminalis</i> Sayed; <i>Oligonychus terminalis</i> (Sayed) Basionym: <i>Paratetranychus mangiferus</i> Rahman & Sapro; [Acarina: Tetranychidae]	Mango red spider mite	Yes	Yes (Lee, 1988)	Yes (Halliday, 1998; 2000)		No
<i>Tegonotus mangiferae</i> (Keifer) [Acarina: Eriophyidae]	Mango leaf rust mite	Yes	Yes (Huang <i>et al.</i> , 1990)	Yes (Knihinicki & Boczek, 2002)		No
<i>Tegonotus paramangiferae</i> (Huang <i>et al.</i> , 1989) [Acarina: Eriophyidae]		No	Yes (Huang <i>et al.</i> , 1990)	No (Halliday, 1998; 2000)	No. A pest of mango trees in Taiwan (Huang <i>et al.</i> , 1990).	No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Tetranychus cinnabarinus</i> (Boisduval, 1867) [Acarina: Tetranychidae]	Carmine spider mite	Yes	Yes (Anon, 1980)	Yes (Halliday, 1998; 2000)		No
<i>Tyrophagus longior</i> (Gervais, 1844) [Acarina: Tetranychidae]	Seed mite	Yes	Yes (Tjying, 1970; 1971)	Yes (Halliday, 1998; 2000)		No
INSECTA						
COLEOPTERA						
<i>Anomala anthusa</i> Ohaus [Coleoptera: Scarabaeidae]		No	Yes (Lee, 1988)	No (Cassis <i>et al.</i> , 2002)	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No
<i>Anomala cypriogastra</i> Ohaus Recorded as: <i>Anomala ypryogastra</i> [sic.] Ohaus in BAPHIQ (2004) [Coleoptera: Scarabaeidae]		No	Yes (Lee, 1988; BAPHIQ, 2004)	No (Cassis <i>et al.</i> , 2002)	No. Can cause considerable damage to mango trees (Lee, 1988). Minor pest, affecting leaves of mango trees in Taiwan (BAPHIQ, 2004).	No
<i>Anomala expansa</i> Bates [Coleoptera: Scarabaeidae]	May beetle	No	Yes (Lee, 1988; BAPHIQ, 2004)	No (Cassis <i>et al.</i> , 2002)	No. Can cause considerable damage to mango trees (Lee, 1988). Minor pest, affecting leaves of mango trees in Taiwan (BAPHIQ, 2004).	No
<i>Anomala siniopyga</i> Ohaus [Coleoptera: Scarabaeidae]		No	Yes (Lee, 1988)	No (Cassis <i>et al.</i> , 2002)	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No
<i>Anomala trachypyga</i> Bates Syn: <i>Euchlora trachypyga</i> Bates [Coleoptera: Scarabaeidae]		No	Yes (Lee, 1988)	No (Cassis <i>et al.</i> , 2002)	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Crossotarsus externedentatus</i> (Fairmaire, 1849) [Coleoptera: Platypodidae]	Stem borer	Yes	Yes (Wood & Bright, 1992; Beaver & Shih, 2003; Huang <i>et al.</i> , 2003)	Yes (Wood & Bright, 1992)		No
<i>Deporaus marginatus</i> (Pascoe, 1883) [Coleoptera: Curculionidae]	Mango leaf cutting weevil	Yes	Yes (CAB International, 2005)	No (CAB International, 2005)	No. Eggs are laid on the leaves of the mango plant; both adults and larvae feed on leaves (CAB International, 2005).	No
<i>Diapus quinquespinatus</i> Chapuis, 1865 [Coleoptera: Platypodidae]		No	Yes (Wood & Bright, 1992)	Yes (Wood & Bright, 1992)		No
<i>Eccoptopterus spinosus</i> (Oliver, 1795) [Coleoptera: Scolytidae]		No	Yes (Wood & Bright, 1992)	Yes (Wood & Bright, 1992)		No
<i>Eucorynus crassicornis</i> (Fabricius, 1801) [Coleoptera: Anthribidae]	Tephrosia seed weevil	Yes	Yes (Morimoto, 1979)	Yes (Zimmerman, 1994)		No
<i>Euwallacea interjectus</i> (Blandford, 1894c) [Coleoptera: Scolytidae]		No	Yes (Wood & Bright, 1992)	No (Wood & Bright, 1992)	No. Bores into the trunk of host plants such as <i>Prunus mume</i> and <i>Brownea capitella</i> (Huang <i>et al.</i> , 2003).	No
<i>Hypomeces squamosus</i> (Fabricius, 1792) [Coleoptera: Curculionidae]	Green weevil	Yes	Yes (Clausen, 1933; CAB International, 2005)	No (CAB International, 2005)	No. Mango is a minor host; adults feed on leaves and larvae feed on roots (CAB International, 2005).	No
<i>Hypothenemus javanus</i> (Eggers, 1908c) [Coleoptera: Scolytidae]		No	Yes (Wood & Bright, 1992)	No (Wood & Bright, 1992)	No. Breeds within the pith of twigs of a wide variety of hosts (Atkinson & Peck, 1994).	No
<i>Hypothenemus setosus</i> (Eichhoff, 1868e) [Coleoptera: Scolytidae]		No	Yes (Wood & Bright, 1992)	No (Wood & Bright, 1992)	No. Breeds within the pith of twigs of a wide variety of hosts (Atkinson & Peck, 1994). In Malaysia, it bores into the wood of <i>Dyera costulata</i> and <i>Sindora sp.</i> (Norhara, 1981).	No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Lepidiota nana</i> Sharp [Coleoptera: Scarabaeidae]		No	Yes (Lee, 1988)	No (Cassis <i>et al.</i> , 2002)	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No
<i>Platypus jansonii</i> Chapuis, 1865 [Coleoptera: Platypodidae]		No	Yes (Wood & Bright, 1992)	Yes (Wood & Bright, 1992)		No
<i>Platypus solidus</i> Walker, 1859 [Coleoptera: Platypodidae]	Stem borer	Yes	Yes (Wood & Bright, 1992; Beaver & Shih, 2003)	Yes (Wood & Bright, 1992)		No
<i>Protaetia brevitarsis</i> Lewis [Coleoptera: Cetoniidae]		No	Yes (Chiu, 1991)	No (Booth <i>et al.</i> , 1990)	No. Adult cetonids generally feed on tree sap and leaves; larvae feed on roots and rotten timber (Booth <i>et al.</i> , 1990).	No
<i>Sinoxylon mangifera</i> Chujo [Coleoptera: Bostrichidae]		No	Yes (Lee, 1988)	No records found	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No
<i>Xyleborus haberkorni</i> Eggers, 1920 [Coleoptera: Scolytidae]		No	Yes (Wood & Bright, 1992)	No (Wood & Bright, 1992)	No. <i>Xyleborus</i> spp are generally stem borers.	No
<i>Xyleborus metacuneolus</i> Eggers, 1940d [Coleoptera: Scolytidae]		No	Yes (Wood & Bright, 1992)	No (Wood & Bright, 1992)	No. <i>Xyleborus</i> spp are generally stem borers.	No
<i>Xyleborus perforans</i> (Wollaston, 1857) [Coleoptera: Scolytidae]	Island pinhole borer	Yes	Yes (Wood & Bright, 1992)	Yes (Wood & Bright, 1992)		No
<i>Xyleborus similis</i> Ferrari, 1867 [Coleoptera: Scolytidae]		No	Yes (Wood & Bright, 1992)	Yes (Wood & Bright, 1992)		No
<i>Xylopsocus capucinus</i> (Fabricius, 1781) [Coleoptera: Bostrichidae]	False powder-post beetle	No	Yes (Lee, 1988)	Yes (USDA, 2001)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Xylosandrus compactus</i> (Eichhoff, 1875) [Coleoptera: Scolytidae]	Chestnut beetle	Yes	Yes (Wood & Bright, 1992)	No (Wood & Bright, 1992)	No. Borer of seedlings, shoots and twigs of mango and other hosts in Florida, USA (Wolfenbarger, 1973; Ngoan <i>et al.</i> , 1976).	No
<i>Xylosandrus crassiusculus</i> (Motschulsky, 1866) [Coleoptera: Scolytidae]	Asian ambrosia beetle	No	Yes (Wood & Bright, 1992)	No (Wood & Bright, 1992)	No. Bores into roots, stems and branches of mango trees in Pakistan (Khuhro <i>et al.</i> , 2005).	No
<i>Xylosandrus discolor</i> (Blandford, 1898) [Coleoptera: Scolytidae]		No	Yes (CAB International, 2005)	No (CAB International, 2005)	No. Mango is a minor host and stems of host trees are attacked by this species (CAB International, 2005)	No
<i>Xylosandrus mancus</i> (Blandford, 1898a) [Coleoptera: Scolytidae]		No	Yes (Wood & Bright, 1992)	No (Wood & Bright, 1992)	No. <i>Xylosandrus</i> spp. are generally stem borers.	No
DIPTERA						
<i>Bactrocera cucurbitae</i> (Coquillett, 1899) Syn: <i>Dacus cucurbitae</i> [Diptera: Tephritidae]	Melon fruit fly	Yes	Yes (Wen, 1985; Chang <i>et al.</i> , 2003; Lin <i>et al.</i> , 2005)	No (Hardy & Foote, 1996)	Yes. The female selects mature mango fruit and lays eggs through the skin, into the fruit pulp in Taiwan (Lin <i>et al.</i> , 1976).	Yes
<i>Bactrocera dorsalis</i> (Hendel, 1912) Syn: <i>Bactrocera ferruginea</i> Fabricius, 1794 [Diptera: Tephritidae]	Oriental fruit fly	Yes	Yes (Lee, 1988; Hardy & Foote, 1996; Tandon, 1998; Chang <i>et al.</i> , 2003; Lin <i>et al.</i> , 2005)	No (Hardy & Foote, 1996)	Yes. The female selects mature mango fruit and lays eggs through the skin, into the fruit pulp (Lee, 1988). Commonly occur on mango fruit in Taiwan (Chiu, 1991).	Yes
<i>Bactrocera latifrons</i> (Hendel, 1915) [Diptera: Tephritidae]	Solanum fruit fly	No	Yes (Hardy & Foote, 1996)	No (Hardy & Foote, 1996)	Yes. Attacks mango fruit in Thailand (Karnkowski <i>et al.</i> , 2003) and Malaysia (Liquido <i>et al.</i> , 1994)	Yes
<i>Bactrocera tau</i> (Walker) [Diptera: Tephritidae]	Fruit fly	Yes	Yes (Chang <i>et al.</i> , 2003; Lin <i>et al.</i> , 2005)	No (Hardy & Foote, 1996)	Yes. Infests mango fruit in Sri Lanka and India (Grewal & Kapoor, 1986; Ekanayake & Bandara, 2003)	Yes

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
HEMIPTERA						
<i>Abgrallaspis cyanophylli</i> (Signoret, 1869) Syn: <i>Hemiberlesia cyanophylli</i> (Signoret) [Hemiptera: Diaspididae]	Cyanophyll scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Donaldson & Tsang, 2002). Not in WA (DAWA, 2003).	Yes. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), and feasibly associated with fruit.	Yes
<i>Aleurocanthus woglumi</i> Ashby, 1915 [Hemiptera: Aleyrodidae]	Citrus blackfly	Yes	Yes (EPPO, 2005)	No (EPPO, 2005)	No. Eggs and immature stages can occur on the underside of mango leaves (EPPO, 2005). Mango fruit can be cosmetically affected by secondary sooty mould development on honeydew produced by this species (EPPO, 2005).	No
<i>Aleurodicus dispersus</i> Russell, 1965 [Hemiptera: Aleyrodidae]	Spiralling whitefly	Yes	Yes (Wen <i>et al.</i> , 1997)	Yes (Mani & Krishnamoorthy, 2002)		No
<i>Aonidiella aurantii</i> (Maskell, 1879) [Hemiptera: Diaspididae]	California red scale	Yes	Yes (Lee, 1988; BAPHIQ, 2004; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Aonidiella citrina</i> (Craw, 1890) [Hemiptera: Diaspididae]	Citrus yellow scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Aonidiella inornata</i> McKenzie, 1938 [Hemiptera: Diaspididae]	Armoured scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Aonidomytilus albus</i> (Cockerell) [Hemiptera: Diaspididae]	Tapioca scale	No	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), and feasibly associated with fruit.	Yes

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Aspidiotus destructor</i> Signoret, 1869 [Hemiptera: Diaspididae]	Coconut scale, transparent scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Aulacaspis rosae</i> (Bouché, 1833) [Hemiptera: Diaspididae]	Mango snow scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Aulacaspis tubercularis</i> Newstead, 1906 [Hemiptera: Diaspididae]	Mango scale; white mango scale	Yes	Yes (Lee, 1988; BAPHIQ, 2004; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Aulacaspis vitis</i> (Green, 1896) [Hemiptera: Diaspididae]	Armoured scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), and feasibly associated with fruit.	Yes
<i>Calophya mangiferae</i> Burckhardt & Basset Syn: <i>Microceropsylla nigra</i> (Crawford) Recorded as <i>Croceropsylla</i> [sic.] <i>nigra</i> Crawford in BAPHIQ (2004) [Hemiptera: Calophyidae]	Mango psyllid	No	Yes (Lee, 1988; BAPHIQ, 2004)	Yes (Hollis, 2005)		No
<i>Ceroplastes ceriferus</i> (Fabricius, 1798) [Hemiptera: Coccidae]	Indian wax scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Ceroplastes floridensis</i> Comstock Syn: <i>Paracerostegia floridensis</i> (Comstock) [Hemiptera: Coccidae]	Florida wax scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Ceroplastes pseudoceriferus</i> (Green) Recorded as <i>Ceroplastes pseudoceriferens</i> [sic.] in Lee (1988) [Hemiptera: Coccidae]		Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	No (Swirski <i>et al.</i> , 1997; Ben-Dov <i>et al.</i> , 2005)	No. Infestations of mangoes cause wilting of leaves, malformation of flowers, and failure of twigs to produce flowers (Swirski <i>et al.</i> , 1997).	No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Ceroplastes rubens</i> Maskell, 1893 [Hemiptera: Coccidae]	Pink wax scale	Yes	Yes (Lee, 1988; Wen <i>et al.</i> , 2002; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Chrysomphalus aonidum</i> (Linnaeus, 1758) Syn: <i>Chrysomphalus ficus</i> Ashmead [Hemiptera: Diaspididae]	Florida red scale	Yes	Yes (Lee, 1988; BAPHIQ, 2004; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Chrysomphalus dictyospermi</i> (Morgan, 1889) [Hemiptera: Diaspididae]	Spanish red scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Coccus discrepans</i> (Green, 1904) [Hemiptera: Coccidae]	Soft scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	No. Pest affects leaves of mango trees (USDA, 2001).	No
<i>Coccus hesperidum</i> Linnaeus, 1758 [Hemiptera: Coccidae]	Brown soft scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Coccus longulus</i> (Douglas, 1887) [Hemiptera: Coccidae]	Long soft scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Coccus viridis</i> (Green, 1889) [Hemiptera: Coccidae]	Green coffee scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Diaspis bromeliae</i> Signoret [Hemiptera: Diaspididae]		No	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Duplachionaspis graminis</i> (Green) [Hemiptera: Diaspididae]		No	Yes (Lee, 1988)	No (Ben-Dov <i>et al.</i> , 2005)	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No
<i>Duplaspidotus claviger</i> (Cockerell) [Hemiptera: Diaspididae]		No	Yes (Lee, 1988)	Yes (Donaldson & Tsang, 2002)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Dysmicoccus brevipes</i> (Cockerell, 1893) [Hemiptera: Pseudococcidae]	Pineapple mealybug	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Eucalymnatus tessellatus</i> (Signoret, 1873) Recorded as: <i>Eucalymnatus tessellates</i> [sic.] in Lee (1988) [Hemiptera: Coccidae]	Palm scale, tessellated scale	No	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Ferrisia virgata</i> (Cockerell, 1893) [Hemiptera: Pseudococcidae]	Striped mealybug	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Fiorinia fioriniae</i> (Targioni Tozzetti, 1867) [Hemiptera: Diaspididae]	Avocado scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Fiorinia proboscidaria</i> Green [Hemiptera: Diaspididae]		No	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	No. Attacks leaves and branches of citrus in China (Kuwana, 1931).	No
<i>Hemiberlesia lataniae</i> (Signoret, 1869) [Hemiptera: Diaspididae]	Latania scale, palm scale, grape vine scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Hemiberlesia rapax</i> (Comstock, 1881) Misidentified as: <i>Aspidiotus camelliae</i> Signoret in Lee (1988) [Hemiptera: Diaspididae]	Greedy scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Howardia biclavis</i> (Comstock) [Hemiptera: Diaspididae]		No	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Icerya aegyptiaca</i> (Douglas, 1890) [Hemiptera: Margarodidae]	Egyptian fluted scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (CAB International, 2005)	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988).	No
<i>Icerya purchasi</i> Maskell, 1879 [Hemiptera: Margarodidae]	Cottony cushion scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Icerya seychellarum</i> (Westwood, 1855) Syn: <i>Icerya okadae</i> Kuwana [Hemiptera: Margarodidae]	Seychelles scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Idioscopus clypealis</i> (Lethierry, 1889) [Hemiptera: Cicadellidae]	Mango green leafhopper	Yes	Yes (Lee, 1988; Tandon, 1998; Wen, 2000; BAPHIQ, 2004)	Yes (Fletcher & Dangerfield, 2002)		No
<i>Idioscopus nitidulus</i> (Walker, 1870) Syn: <i>Idioscopus niveosparsus</i> Lethierry, 1889 in BAPHIQ (2004) [Hemiptera: Cicadellidae]	Mango brown leafhopper	Yes	Yes (Lee, 1988; Tandon, 1998; Wen, 2000; BAPHIQ, 2004)	Yes (Day & Fletcher, 1994; Fletcher & Dangerfield, 2002)		No
<i>Ischnaspis longirostris</i> (Signoret, 1882) Syn: <i>Ischnaspis filiformis</i> Douglas [Hemiptera: Diaspididae]	Black thread scale, black line scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Kerria greeni</i> (Chamberlin) Syn: <i>Laccifer greeni</i> (Camberlin) [Hemiptera: Kerriidae]		No	Yes (Takahashi, 1928; Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	No. Species of this genus are known to attack stems (BAPHIQ, 2004).	No
<i>Kerria lacca</i> (Kerr, 1782) [Hemiptera: Kerriidae]	Lac insect	Yes	Yes (Lee, 1988; Wen <i>et al.</i> , 2002; BAPHIQ, 2004)	No (Ben-Dov <i>et al.</i> , 2005)	No. This species attack stems of mango in Taiwan (BAPHIQ, 2004).	No
<i>Kilifia acuminata</i> (Signoret, 1873) [Hemiptera: Coccidae]	Acuminate scale, mango shield scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	No. Attacks leaves of mangoes in North America (Peña & Mohyuddin, 1997).	No
<i>Lepidosaphes beckii</i> (Newman, 1869) [Hemiptera: Diaspididae]	Mussel scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Lepidosaphes gloverii</i> (Packard, 1869) Syn: <i>Insulaspis gloverii</i> (Packard) [Hemiptera: Diaspididae]	Glover's scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Lepidosaphes laterochitinsa</i> Green Syn: <i>Parainsulaspis laterochitinsa</i> (Green) [Hemiptera: Diaspididae]	Armoured scale	No	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), and feasibly associated with fruit.	Yes
<i>Lindingaspis proteus</i> (Curtis) [Hemiptera: Diaspididae]		No	Yes (Lee, 1988)	No records found	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No
<i>Lindingaspis rossi</i> (Maskell, 1891) [Hemiptera: Diaspididae]	Circular black scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Maconellicoccus hirsutus</i> (Green, 1908) [Hemiptera: Pseudococcidae]	Pink hibiscus mealybug	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Milviscutulus mangiferae</i> (Green, 1889) Syn: <i>Protopulvinaria mangiferae</i> (Green) Basionym: <i>Coccus mangiferae</i> Green [Hemiptera: Coccidae]	Mango shield scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes—But distribution is limited to Cape York Peninsula, Queensland (Blüthgen <i>et al.</i> , 2003; NAQS, 2003)	Yes. Branch, fruit, leaf, trunk of mango trees in Israel (Peña & Mohyuddin, 1997)	Yes
<i>Morganella longispina</i> (Morgan, 1889) [Hemiptera: Diaspididae]	Maskell scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Nipaecoccus viridis</i> (Newstead, 1894) Syn: <i>Nipaecoccus vastator</i> [Hemiptera: Pseudococcidae]	Spherical mealybug	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Paralecanium expansum</i> (Green, 1896) [Hemiptera: Coccidae]	Flat scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Parasaissetia nigra</i> (Nietner, 1861) [Hemiptera: Coccidae]	Nigra scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Paratachardina theae</i> Green, 1907 [Hemiptera: Kerriidae]	Scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	No. Inadequate biology data concerning this species. However, <i>P. lobata lobata</i> is not associated with fruit or leaves, attacking small diameter branches and stems of mango in Florida, USA (Howard <i>et al.</i> , 2004a; Howard <i>et al.</i> , 2004b; Pemberton, 2004).	No
<i>Parlatoria camelliae</i> Comstock, 1883 [Hemiptera: Diaspididae]	Camellia parlatoria scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Parlatoria oleae</i> (Colvée, 1880) [Hemiptera: Diaspididae]	Olive scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Parlatoria proteus</i> (Curtis) [Hemiptera: Diaspididae]		No	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Parlatoria pseudaspidotus</i> Lindinger, 1905 Syn: <i>Parlatoria mangiferae</i> Marlatt, 1908 Recorded as the syn: <i>Parlatoria mangiferae</i> in the Prelim. Taiwan mango PRA [Hemiptera: Diaspididae]	Vanda orchid scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), and feasibly associated with fruit.	Yes
<i>Pinnaspis aspidistrae</i> (Signoret, 1869) [Hemiptera: Diaspididae]	Aspidistra scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Pinnaspis strachani</i> (Cooley, 1899) [Hemiptera: Diaspididae]	Cotton white scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Planococcus citri</i> (Risso, 1813) [Hemiptera: Pseudococcidae]	Citrus mealybug	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Planococcus lilacinus</i> (Cockerell, 1905) [Hemiptera: Pseudococcidae]	Coffee mealybug	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a minor host but pest can damage the whole tree including fruit (CAB International, 2005).	Yes
<i>Planococcus minor</i> (Maskell, 1897) [Hemiptera: Pseudococcidae]	Pacific mealybug	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Platysaissetia formicarii</i> (Green) Syn: <i>Coccus formicarii</i> (Green, 1896) Recorded as: <i>Saissetia formicarii</i> in Lee (1988) [Hemiptera: Coccidae]	Soft scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	No. A pest of mango leaves in India (USDA, 2001).	No
<i>Prococcus acutissimus</i> (Green, 1896) Syns: <i>Leacnium acutissimum</i> Green; <i>Coccus acutissimus</i> (Green) [Hemiptera: Coccidae]	Banana-shaped scale; slender soft scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	No. Pest affects leaves of mango trees (Peña & Mohyuddin, 1997).	No
<i>Protopulvinaria pyriformis</i> (Cockerell) [Hemiptera: Coccidae]	Pyriform scale	No	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), and feasibly associated with fruit.	Yes
<i>Pseudaonidia trilobitiformis</i> (Green, 1896) [Hemiptera: Diaspididae]	Trilobite scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Pseudaulacaspis cockerelli</i> (Cooley, 1897) [Hemiptera: Diaspididae]	False oleander scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No

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		* the Philippines and/or India	Taiwan			
<i>Pseudaulacaspis pentagona</i> (Targioni Tozzetti, 1886) [Hemiptera: Diaspididae]	Mulberry scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Pseudococcus cryptus</i> Hempel [Hemiptera: Pseudococcidae]	Citriculus mealybug	No	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), and feasibly associated with fruit.	Yes
<i>Pseudococcus jackbeardsleyi</i> Gimpel & Miller [Hemiptera: Pseudococcidae]	Jack Beardsley mealybug	No	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a minor host but pest attacks fruit and leaves (CAB International, 2005)	Yes
<i>Pseudococcus longispinus</i> (Targioni Tozzetti, 1867) Missidentification: <i>Pseudococcus adonidum</i> (Westwood) in Lee (1988) [Hemiptera: Pseudococcidae]	Long-tailed mealybug	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Pulvinaria polygonata</i> Cockerell, 1905 [Hemiptera: Coccidae]	Cottony citrus scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Pulvinaria psidii</i> Maskell, 1893 Syn: <i>Chloropulvinaria psidii</i> (Maskell) [Hemiptera: Coccidae]	Green shield scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Pulvinaria taiwana</i> Takahashi [Hemiptera: Coccidae]	Scale	No	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), and feasibly associated with fruit.	Yes
<i>Rastrococcus spinosus</i> (Robinson, 1918) [Hemiptera: Pseudococcidae]	Philippine mango mealybug	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a major host (CAB International, 2005)	Yes
<i>Saissetia coffeae</i> (Walker, 1852) [Hemiptera: Coccidae]	Hemispherical scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Saissetia hemisphaerica</i> (Targioni-Tozzetti, 1948) [Hemiptera: Coccidae]	Scale	No	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Saissetia oleae</i> (Olivier, 1791) [Hemiptera: Coccidae]	Black scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Selenaspidus articulatus</i> (Morgan) [Hemiptera: Diaspididae]	Armoured scale	No	Yes (Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No
<i>Semelaspidus mangiferae</i> Takahashi, 1939 Recorded as: <i>Semilaspidus</i> [sic.] <i>mangiferae</i> in Indian mango Draft review. [Hemiptera: Diaspididae]	Armoured scale	Yes	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	No. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), Reported only on mango branches and leaves (Takahashi, 1939) and leaves (Nafus, 1997).	No
<i>Sophonia rufofascia</i> Kuoh & Kuoh, 1983 [Hemiptera: Cicadellidae]	Two-spotted leafhopper	No	Yes (CAB International, 2005)	No (CAB International, 2005)	No. Mango is a major host but this species feeds on leaves causing dieback (CAB International, 2005).	No
<i>Toxoptera citricida</i> (Kirkaldy) [Hemiptera: Aphididae]	Aphid	No	Yes (Tao & Wu, 1968)	Yes (CAB International, 2005)		No
<i>Toxoptera odinae</i> (van der Goot, 1917) [Hemiptera: Aphididae]	Mango aphid	Yes	Yes (Lee, 1988; Blackman & Eastop, 2000; BAPHIQ, 2004)	No records found	Yes. Affects leaves, flowers and fruit of mango in Taiwan (BAPHIQ, 2004).	Yes
<i>Unaspis acuminata</i> (Green) [Hemiptera: Diaspididae]	Unaspis scale	No	Yes (Ben-Dov <i>et al.</i> , 2005)	No (Ben-Dov <i>et al.</i> , 2005)	Yes. Mango is a host of this species (Ben-Dov <i>et al.</i> , 2005), and feasibly associated with fruit.	Yes
<i>Vinsonia stellifera</i> (Westwood, 1871) [Hemiptera: Coccidae]	Stellate scale	Yes	Yes (Lee, 1988; Ben-Dov <i>et al.</i> , 2005)	Yes (Ben-Dov <i>et al.</i> , 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
HYMENOPTERA						
<i>Anoplolepis gracilipes</i> (Smith, 1857) [Hymenoptera: Formicidae]	Crazy ant; long legged ant	Yes	Yes (ISSG, 2005)	Yes (ISSG, 2005)		No
ISOPTERA						
<i>Coptotermes formosanus</i> Shiraki, 1909 [Isoptera: Rhinotermitidae]	Formosan subterranean termite	Yes	Yes (Su & Hsu, 2003)	No (Watson & Abbey, 1993; Watson <i>et al.</i> , 1998)	No. Attacks trunk of mango trees in North America (Peña & Mohyuddin, 1997).	No
LEPIDOPTERA						
<i>Acherontia styx</i> (Westwood, 1847) [Lepidoptera: Sphingidae]	Indian death's head hawkmoth	Yes	Yes (Lin, 1987)	No (Nielsen <i>et al.</i> , 1996)	No. Eggs are laid on leaves, larvae feed on leaves and shoots and pupate in the soil (CAB International, 2005).	No
<i>Acrocercops astaurota</i> Meyrick Syn: <i>Spulerina astaurota</i> (Meyrick) [Lepidoptera: Gracillariidae]	Mango leaf miner	No	Yes (Lee, 1988; BAPHIQ, 2004)	No (Nielsen <i>et al.</i> , 1996)	No. Causes serious damage to newly developing leaves and the epidermis of tender shoots on mango trees in Taiwan (Lee, 1988).	No
<i>Acrocercops cathedraea</i> Meyrick Syn: <i>Telamoptilia cathedraea</i> (Meyrick, 1908) [Lepidoptera: Gracillariidae]	Leaf miner	Yes	Yes (De Prins, 2002)	No (Nielsen <i>et al.</i> , 1996)	No. Damages leaves of mango in India (Robinson <i>et al.</i> , 2004).	No
<i>Agrius convolvuli</i> (Linnaeus, 1758) [Lepidoptera: Sphingidae]	Sweet potato moth	Yes	Yes (CAB International, 2005)	Yes (Nielsen <i>et al.</i> , 1996)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Amsacta lactinea</i> (Cramer) [Lepidoptera: Arctiidae]	Red tiger moth; black hairy caterpillar	Yes	Yes (Zhang, 1994)	No (Nielsen <i>et al.</i> , 1996)	No. Feeds on leaves of mango in India (Srivastava, 1997).	No
<i>Attacus atlas</i> (Linnaeus, 1758) [Lepidoptera: Saturniidae]	Atlas moth	Yes	Yes (Heppner <i>et al.</i> , 1989; Paukstadt & Paukstadt, 2002)	No (Nielsen <i>et al.</i> , 1996)	No. Attacks leaves of mango in Indonesia (Robinson <i>et al.</i> , 2004).	No
<i>Cadra cautella</i> (Walker, 1863) [Lepidoptera: Pyralidae]	Almond moth	Yes	Yes (CAB International, 2005)	Yes (CAB International, 2005)		No
<i>Chlumetia transversa</i> (Walker, 1863) Syns: <i>Chlumetia guttiventris</i> Walker; <i>Ariola corticea</i> Snellen; <i>Chlumetia guangxiensis</i> Wu & Zhu; <i>Salagena transversa</i> (Walker); <i>Sholumetia transversa</i> (Walker) Basionym: <i>Nachaba transversa</i> Walker [Lepidoptera: Noctuidae]	Mango shoot borer; mango shoot caterpillar; mango tip borer	Yes	Yes (Lee, 1988; Tandon, 1998; BAPHIQ, 2004)	Yes (Nielsen <i>et al.</i> , 1996)		No
<i>Conogethes punctiferalis</i> (Guenée, 1854) [Lepidoptera: Pyralidae]	Castor seed caterpillar	Yes	Yes (CAB International, 2005)	Yes (CAB International, 2005)		No
<i>Dasychira mendosa</i> Hübner Syn: <i>Olene mendosa</i> Hübner, 1823 [Lepidoptera: Lymantriidae]	Tussock caterpillar	Yes	Yes (Zhang, 1994)	Yes (Nielsen <i>et al.</i> , 1996)		No
<i>Dudua aprobola</i> (Meyrick, 1886) [Lepidoptera: Tortricidae]	Moth	Yes	Yes (Meijerman & Ulenberg, 2005)	Yes (Nielsen <i>et al.</i> , 1996)		No
<i>Eucosma melanoneura</i> Meyrick [Lepidoptera: Tortricidae]		No	Yes (Lee, 1988)	No (Nielsen <i>et al.</i> , 1996)	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Eudocima fullonia</i> (Clerck, 1764) [Lepidoptera: Noctuidae]	Fruit piercing moth	Yes	Yes (CAB International, 2005)	Yes (Nielsen <i>et al.</i> , 1996)		No
<i>Eudocima salamina</i> (Cramer, 1777) [Lepidoptera: Noctuidae]		No	Yes (Kluesener, 1994)	Yes (Fay & Halfpapp, 1999)		No
<i>Eumeta variegata</i> Niitsu Syns: <i>Eumeta preyeri</i> (Leech); <i>Clania preyeri</i> Leech; <i>Cryptothelea formosicola</i> Strand [Lepidoptera: Psychidae]	Giant bag-worm	No	Yes (Lee, 1988; BAPHIQ, 2004)	Yes (APPD, 2005)		No
<i>Euproctis scintillans</i> (Walker, 1856) [Lepidoptera: Lymantriidae]	Tussock caterpillar	Yes	Yes (Lin, 2002)	No (Nielsen <i>et al.</i> , 1996)	No. Occurs on leaves of mango in India (Srivastava, 1997).	No
<i>Euproctis taiwana</i> (Shiraki) Recorded as the Basionym: <i>Porthesia taiwana</i> Shiraki in BAPHIQ (2004) [Lepidoptera: Lymantriidae]	Tussock moth	No	Yes (BAPHIQ, 2004)	No (Nielsen <i>et al.</i> , 1996)	No. BAPHIQ (2004) correspondence reports that this species occurs on leaves, flowers and fruit of mango in Taiwan. However, the literature indicates that this species feeds on the leaves of gladiolus and lily plants (Liu, 1998), the leaves of soybean (Talekar <i>et al.</i> , 1988), leaves of grapevine (Chang, 1988) and the leaves of rose (Wang, 1982) in Taiwan.	No
<i>Heleanna melanomochla</i> Meyrick [Lepidoptera: Tortricidae]		No	Yes (Robinson <i>et al.</i> , 2004)	No (Nielsen <i>et al.</i> , 1996)	No. Found on leaves of mango in Taiwan (Robinson <i>et al.</i> , 2004).	No
<i>Helicoverpa armigera</i> (Hübner, 1805) [Lepidoptera: Noctuidae]	Cotton bollworm	Yes	Yes (CAB International, 2005)	Yes (Nielsen <i>et al.</i> , 1996)		No
<i>Homona coffearia</i> (Nietner, 1861) [Lepidoptera: Tortricidae]	Coffee tortrix	Yes	Yes (CAB International, 2005)	Yes (CAB International, 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Lymantria mathura</i> Moore, 1865 [Lepidoptera: Lymantriidae]	Rosy (pink) gypsy moth	Yes	Yes (Zhang, 1994)	No (Nielsen <i>et al.</i> , 1996)	No. Found on leaves of mango in India (Srivastava, 1997; Robinson <i>et al.</i> , 2004).	No
<i>Maruca vitrata</i> (Fabricius, 1787) [Lepidoptera: Pyralidae]	Bean pod borer	Yes	Yes (CAB International, 2005)	Yes (Nielsen <i>et al.</i> , 1996)		No
<i>Orgyia australis postica</i> (Walker, 1855) Regarded by some authors to be <i>Orgyia postica</i> (Walker, 1855) Recorded as <i>Notolophorus australis posticus</i> Walker [sic.] in BAPHIQ (2004) [Lepidoptera: Lymantriidae]	Cocoa tussock moth	Yes	Yes (Lee, 1988; BAPHIQ, 2004)	No (CAB International, 2005)	Yes. Mango is a major host of this species; it affects the leaves (CAB International, 2005), flowers and fruit (BAPHIQ, 2004).	Yes
<i>Parasa lepida</i> (Cramer, 1799) [Lepidoptera: Limacodidae]	Nettle caterpillar	Yes	Yes (Yanagita & Nakao, 2005)	No (Nielsen <i>et al.</i> , 1996)	No. Feeds on leaves of mango in India (Kapoor <i>et al.</i> , 1985; Jeyabalan & Murugan, 1996).	No
<i>Penicillaria jocosatrix</i> (Guenée) Syn: <i>Bombotelia jocosatrix</i> (Guenée) [Lepidoptera: Noctuidae]	Large mango tip borer	Yes	Yes (Lee, 1988)	Yes (Nielsen <i>et al.</i> , 1996)		No
<i>Perina nuda</i> (Fabricius, 1787) [Lepidoptera: Lymantriidae]	Clear-winged tussock moth	Yes	Yes (Zhang, 1994)	No (Nielsen <i>et al.</i> , 1996)	No. Feeds on leaves of mango in India (Srivastava, 1997)	No
<i>Pingasa ruginaria</i> Guenée [Lepidoptera: Geometridae]		No	Yes (Lee, 1988)	No (Nielsen <i>et al.</i> , 1996)	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No
<i>Pyroderces simplex</i> Walsingham [Lepidoptera: Cosmopterigidae]	Flower eating caterpillar	Yes	Yes (Zhang, 1994)	No (Nielsen <i>et al.</i> , 1996)	No. Found on flowers of mango in India (Robinson <i>et al.</i> , 2004)	No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Scirpophaga excerptalis</i> Walker, 1863 [Lepidoptera: Pyralidae]	Sugarcane top borer	Yes	Yes (CAB International, 2005)	Yes (Nielsen <i>et al.</i> , 1996). Not in WA (DAWA, 2003)	No. Mango is a minor host and this species attacks leaves, shoots and growing points (CAB International, 2005).	No
<i>Selepa celtis</i> Moore, 1858 [Lepidoptera: Noctuidae]	Aonla hairy caterpillar	Yes	Yes (Holloway, 2005)	Yes (Nielsen <i>et al.</i> , 1996)		No
<i>Spilarctia obliqua</i> Walker Syn: <i>Spilosoma obliqua</i> (Walker, 1865) [Lepidoptera: Arctiidae]	Common hairy caterpillar	Yes	Yes (Zhang, 1994)	No (Nielsen <i>et al.</i> , 1996)	No. Feeds on leaves of mango in India (Srivastava, 1997)	No
<i>Spodoptera litura</i> (Fabricius) [Lepidoptera: Noctuidae]	Armyworm	No	Yes (Lee, 1988; CAB International, 2005)	Yes (Nielsen <i>et al.</i> , 1996)		No
<i>Stauropus alternus</i> Walker [Lepidoptera: Notodontidae]		Yes	Yes (Lee, 1988; Yanagita & Nakao, 2005)	No (Nielsen <i>et al.</i> , 1996)	No. Occurs on branches and leaves of mango in Indonesia (Robinson <i>et al.</i> , 2004)	No
<i>Strepsicrates rhothia</i> (Meyrick) [Lepidoptera: Tortricidae]	Eucalyptus leafroller	Yes	Yes (Zhang, 1994)	No (Nielsen <i>et al.</i> , 1996)	No. Occurs on leaves of mango in India (Robinson <i>et al.</i> , 2004)	No
<i>Thalassodes vararia</i> Guenée [Lepidoptera: Geometridae]		No	Yes (Lee, 1988)	No (Nielsen <i>et al.</i> , 1996)	No. Can cause considerable damage to mango trees in Taiwan (Lee, 1988). No records of fruit attack found.	No
<i>Tirathaba mundella</i> Walker, 1865 [Lepidoptera: Pyralidae]	Oil palm bunch moth	Yes	Yes (Hwang, 2000)	No (Nielsen <i>et al.</i> , 1996)	No. Damages banana fruit in Taiwan (Hwang, 2000). This species bores into young fruit of <i>Mangifera andamanica</i> after fruit set and causes premature dropping of fruit in India (Bhumannavar & Jacob, 1990; Srivastava, 1997)	No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Zeuzera coffeae</i> Nietner [Lepidoptera: Cossidae]	Carpenter worm	No	Yes (Lee, 1988; CAB International, 2005)	No (Nielsen <i>et al.</i> , 1996)	No. Species is a woodboring insect that damages twigs of <i>Annona</i> species in South East Asia. In China and Taiwan, eggs are laid in bark crevices; larvae bore into branches and pupation occurs below the bark surface in longan and lychee plants (Pena <i>et al.</i> , 2002).	No
THYSANOPTERA						
<i>Heliothrips haemorrhoidalis</i> (Bouché, 1833) [Thysanoptera: Thripidae]		Yes	Yes (Chen, 1981)	Yes (Mound, 1996)		No
<i>Megalurothrips distalis</i> (Karny, 1913) [Thysanoptera: Thripidae]		Yes	Yes (CAB International, 2005)	Yes (CAB International, 2005)		No
<i>Rhipiphorothrips cruentatus</i> Hood, 1919 Syn: <i>Rhipiphorothrips karna</i> Ramakrishnan [Thysanoptera: Thripidae]	Mango thrip	Yes	Yes (Lee, 1988; BAPHIQ, 2004)	No (Mound, 1996)	Yes. Occurs on mature leaves of mango trees during the dry season in Taiwan (Lee, 1988). Affects leaves and fruit of mango (BAPHIQ, 2004).	Yes
<i>Scirtothrips dorsalis</i> Hood, 1919 Syn: <i>Neophysopus fragariae</i> Girault [Thysanoptera: Thripidae]	Yellow thrip	Yes	Yes (Lee, 1988; BAPHIQ, 2004)	Yes (Mound, 1996)		No
<i>Selenothrips rubrocinctus</i> (Giard, 1901) [Thysanoptera: Thripidae]	Redbanded thrip	Yes	Yes (Chen, 1981)	Yes (Mound, 1996)		No
<i>Taeniothrips varicornis</i> Moulton Syn: <i>Megalurothrips typicus</i> [Thysanoptera: Thripidae]		No	Yes (Anon., 1980)	Yes (Mound, 2002)		No
<i>Thrips hawaiiensis</i> (Morgan, 1913) [Thysanoptera: Thripidae]	Banana flower thrip	Yes	Yes (Lee, 1988)	Yes (Mound, 1996)		No

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		* the Philippines and/or India	Taiwan			
ALGAE						
<i>Cephaleuros virescens</i> Kunze [Trentepohliales: Trentepohliaceae]	Algal leaf spot	Yes	Yes (Hsieh <i>et al.</i> , 2000)	Yes (Johnson & Hobman, 1982)		No
PATHOGENS						
BACTERIA						
<i>Erwinia carotovora</i> subsp. <i>carotovora</i> (Jones, 1901) Bergey, Harrison, Breed, Hammer & Huntoon, 1923 Syn: <i>Erwinia carotovora</i> (Thomma <i>et al.</i> , 2001) [Enterobacteriaceae]	Bacterial rot	Yes	Yes (CAB International, 2005)	Yes (CAB International, 2005)		No
<i>Erwinia herbicola</i> (Löhnis, 1911) Dye, 1964 [Enterobacteriaceae]	Bacterial grapevine blight	Yes	Yes (CAB International, 2005)	Yes (CAB International, 2005)		No
<i>Xanthomonas campestris</i> pv. <i>mangiferaeindicae</i> (Patel, Moniz & Kulkarni, 1948) Robbs, Ribeiro & Kimura, 1974 Syns: <i>Pseudomonas mangiferae indicae</i> Patel; <i>Erwinia mangiferae</i> var. <i>indicae</i> Stapp [Xanthomonadaceae]	Bacterial canker	Yes	Yes (Bradbury, 1986; BAPHIQ, 2004)	Yes (Bradbury, 1986)		No

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		* the Philippines and/or India	Taiwan			
FUNGI						
<i>Acremonium polychromum</i> (J.F.H. Beyma) W. Gams Syn: <i>Gliomastix polychroma</i> (J.F.H. Beyma) Matsushima [Anamorphic Hypocreales]		No	Yes (Matsushima, 1980)	No (APPD, 2005)	No. Recorded as saprophytic in Taiwan (Matsushima, 1980).	No
<i>Alternaria alternata</i> (Fries: Fries) Keissler Syns: <i>Alternaria alternata</i> f.sp. <i>fragariae</i> Dingley; <i>Alternaria alternata</i> f.sp. <i>lycopersici</i> Grogan <i>et al.</i> ; <i>Alternaria fasciculata</i> (Cooke & Ellis) L. Jones & Grout; <i>Alternaria tenuis</i> Nees; <i>Macrosporium fasciculatum</i> Cooke & Ellis; <i>Macrosporium maydis</i> Cooke & Ellis [Anamorphic Lewia]	Alternaria leaf spot	Yes	Yes (CAB International, 2005)	Yes (APPD, 2005)		No
<i>Aspergillus niger</i> var. <i>niger</i> Tieghem Syn: <i>Aspergillus niger</i> van Tieghem [Anamorphic Emericella]	Aspergillus ear rot; black mould	Yes	Yes (CAB International, 2005)	Yes (APPD, 2005)		No
<i>Aspergillus terreus</i> Thom [Anamorphic Emericella]	Stem end rot	Yes	Yes (Chung <i>et al.</i> , 1971)	Yes (APPD, 2005) Not in WA (DAWA, 2003).	No. On stems (Patel <i>et al.</i> , 1985).	No

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		* the Philippines and/or India	Taiwan			
<i>Athelia rolfsii</i> (Curzi) C.C. Tu & Kimbrough Syns: <i>Corticium rolfsii</i> Curzi; <i>Pellicularia rolfsii</i> (Curzi) E. West; <i>Sclerotium rolfsii</i> Saccardo [Polyporales: Atheliaceae]	Collar rot	Yes	Yes (CAB International, 2005)	Yes (APPD, 2005)		No
<i>Aureobasidium pullulans</i> (de Bary) G. Arnaud var. <i>pullulans</i> [Anamorphic: Discosphaerina]	Blue stain	Yes	Yes (Lin <i>et al.</i> , 2004)	Yes (APPD, 2005)		No
<i>Beltraniella portoricensis</i> (F. Stevens) Pirozynski & S.D. Patil Syn: <i>Ellisiopsis gallsiae</i> Batista & Nascimento [Anamorphic: Leiosphaerella]		No	Yes (Matsushima, 1980)	Yes (APPD, 2005) Not in WA (DAWA, 2003)	No. Saprophyte (Matsushima, 1980) found on leaf litter (Farr <i>et al.</i> 1989).	No
<i>Botryosphaeria dothidea</i> (Mougeut: Fries) Cesati & de Notaris [Dothideales: Botryosphaeriaceae]	Fruit rot	Yes	Yes (Ko <i>et al.</i> , 2003)	Yes (APPD, 2005) Not in WA (DAWA, 2004)	No. Inflorescence, leaf, stem (Johnson <i>et al.</i> , 1993). This is a post-harvest disease that affects mango fruit during storage (Johnson <i>et al.</i> , 1993).	No (storage rot)
<i>Botryosphaeria rhodina</i> (Berkeley & M.A. Curtis) Arx Syns: <i>Physalospora rhodina</i> Berkeley & M.A. Curtis; <i>Diplodia natalensis</i> Pole-Evans [Dothideales: Botryosphaeriaceae]	Stem end rot	No	Yes (Anon. 1979)	Yes (APPD, 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Botryosphaeria ribis</i> Grossenbacher & Duggar [Dothideales: Botryosphaeriaceae]	Canker	No	Yes (Kuo <i>et al.</i> , 1989)	Yes (APPD, 2005)		No
<i>Ceratocystis fimbriata</i> Ellis & Halsted [Microascales: Ceratocystidaceae]	Ceratocystis blight	No	Yes (CAB International, 2005)	Yes (APPD, 2005)		No
<i>Ceratocystis paradoxa</i> (Dade) C. Moreau [Microascales: Ceratocystidaceae]	Base rot; black rot; bulb rot	Yes	Yes (CAB International, 2005)	Yes (APPD, 2005) Not in WA (DAWA, 2003)	No. Leaf, root, seed, stem (CAB International, 2005), This is a post-harvest disease (CAB International, 2005).	No
<i>Cercospora mangiferae</i> Koorders Syns: <i>Scolecospigmina mangiferae</i> (Koorders) U. Braun & Mouchacca; <i>Stigmina mangiferae</i> (Koorders) M.B. Ellis [Anamorphic Mycosphaerella]	Stigmina leaf spot	Yes	Yes (Anon., 1979; Hsieh & Goh, 1990)	Yes (Farr <i>et al.</i> , 2005) Not in WA (DAWA, 2003)	No. Leaf (Rawal, 1998).	No
<i>Cladosporium cladosporioides</i> (Fresenius) G.A. de Vries [Anamorphic Mycosphaerella]	Black mould	Yes	Yes (MSRC, 2005)	Yes (APPD, 2005)		No
<i>Colletotrichum acutatum</i> J.H. Simmonds [Anamorphic Glomerella]	Strawberry black spot	Yes	Yes (BAPHIQ, 2004)	Yes (APPD, 2005)		No

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		* the Philippines and/or India	Taiwan			
<i>Colletotrichum orbiculare</i> (Berkeley & Montagne) Arx Syn: <i>Glomerella lagenaria</i> (Passerini) F. Stevens [Phyllachorales: Phyllachoraceae]		No	Yes (Akai <i>et al.</i> , 1958)	Yes (CAB International, 2005)		No
<i>Corticium salmonicolor</i> Berkeley & Broome Syn: <i>Erythriscium salmonicolor</i> (Berkeley & Broome) Burdsall [Polyporales: Corticiaceae]	Pink disease	Yes	Yes (CAB International, 2005)	Yes (APPD, 2005) Not in WA (DAWA, 2003)	No. Bark, branch, trunk (Lim & Khoo, 1985); leaf, stem (CAB International, 2005).	No
<i>Diaporthe citri</i> F.A. Wolf Anamorph: <i>Phomopsis citri</i> H.S. Fawcett [Diaportales: Valsaceae]		Yes	Yes (Tsay & Chuang, 1989)	Yes (CAB International, 2005)		No
<i>Elsinoë mangiferae</i> Bitancourt & Jenkins [Myriangiales: Elsinoaceae]	Mango scab	Yes	Yes (CAB International, 2005)	Yes (APPD, 2005) Not in WA (DAWA, 2003)	Yes. Infects fruit (Condé <i>et al.</i> , 1997).	Yes
<i>Erysiphe cichoracearum</i> Jaczewski [Erysiphales: Erysiphaceae]	Powdery mildew	Yes	Yes (Farr <i>et al.</i> , 2005)	Yes (APPD, 2005)		No
<i>Fusarium oxysporum</i> Schlechtendahl: Fries [Anamorphic: Gibberella]	Mango malformation	Yes	Yes (CAB International, 2005)	Yes (APPD, 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Ganoderma australe</i> (Fries: Fries) Patouillard Syns: <i>Fomes australis</i> (Fries: Fries) Cooke; <i>Polyporus adspersus</i> Schulzer; [Polyporales: Ganodermataceae]		No	Yes (BAPHIQ, 2004)	Yes (APPD, 2005)		No
<i>Ganoderma applanatum</i> (Persoon) Patouillard [Polyporales: Ganodermataceae]	Ornamentals white butt rot	Yes	Yes (Anon. 1979) Misidentification, <i>G. applanatum</i> is replaced by <i>G. australe</i> in the tropics. Distribution overlaps in NW India and Pakistan (Steyaert 1975a,b).	No, Misidentified in APPD (2005). <i>G. applanatum</i> is replaced by <i>G. australe</i> in the tropics. Distribution overlaps in NW India and Pakistan (Steyaert 1975a,b).		No
<i>Gibberella zeae</i> (Schweinitz) Petch [Hypocreales: Nectriaceae]	Cobweb disease	Yes	Yes (CAB International, 2005)	Yes (APPD, 2005)		No
<i>Glomerella cingulata</i> (Stoneman) Spaulding & H. Schrenk Anamorphs: <i>Colletotrichum gloeosporioides</i> (Penzig) Penzig & Saccardo; <i>Gloeosporium mangiferae</i> Henn. [Insertae sedis: Glomerellaceae]	Anthrachnose	Yes	Yes (BAPHIQ, 2004; Anon., 1979)	Yes (APPD, 2005)		No

Scientific name	Common name(s)	Associated with mango in		Present in Australia	Present on importation pathway (mango fruit)	Consider further
		* the Philippines and/or India	Taiwan			
<i>Lasiodiplodia theobromae</i> (Patouillard) Griffon & Maublanc Syn: <i>Botryodiplodia theobromae</i> Patouillard [Aanamorphic: Botryosphaeria]	Bark canker	Yes	Yes (BAPHIQ, 2004)	Yes (APPD, 2005)		No
<i>Macrophomina phaseolina</i> (Tassi) Goidanich [Anamorphic: Ascomycete]	Charcoal rot	Yes	Yes (Wu, 1985)	Yes (APPD, 2005)		No
<i>Meliola mangiferae</i> Earle [Meliolales: Meliolaceae]	Black mildew	Yes	Yes (BAPHIQ, 2004; Anon., 1979)	No (APPD, 2005)	No. Affects fruit and leaves in India (Sharma & Badiyala, 1991). However, this species is a sooty mould, which is considered a cosmetic problem (Nameth <i>et al.</i> , 2003). Sooty mould is easily removed during fruit washing (Laemmlen, 2003).	No
<i>Nectria haematococca</i> Berkely & Broome Anamorph: <i>Fusarium solani</i> (Mortius) Saccardo [Hypocreales: Nectriaceae]	Dry root rot disease	Yes	Yes (CAB International, 2005)	Yes (APPD, 2005)		No
<i>Nectria rigidiuscula</i> Berkely & Broome Anamorph: <i>Fusarium decemcellulare</i> Brick [Hypocreales: Nectriaceae]	Green point gall	No	Yes (CAB International, 2005)	Yes (APPD, 2005) Not in WA (DAWA, 2003)	No. Associated with twigs and branches and galls CAB International, 2005).	No

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		* the Philippines and/or India	Taiwan			
<i>Oidium mangiferae</i> Arthaud-Berthet [Anamorphic: Erysiphe]	Powdery mildew	Yes	Yes (BAPHIQ, 2004; Anon. 1979)	Yes (APPD, 2005)		No
<i>Pestalotiopsis mangiferae</i> (Hennings) Steyaert Syn: <i>Pestalotia mangiferae</i> Hennings [Anamorphic: Pestalosphaeria]	Grey leaf spot of mango	Yes	Yes (Anon. 1979)	Yes (APPD, 2005)		No
<i>Phyllachora pomigena</i> (Schweinitz) Saccardo Syn: <i>Gloeodes pomigena</i> (Schweinitz) Colby [Phyllachorales: Pyllachoraceae]	Sooty blotch	No	Yes (Chao & Wu, 1979)	Yes (APPD, 2005)		No
<i>Phytophthora palmivora</i> (E.J. Butler) E.J. Butler Syns: <i>Phytophthora faberi</i> Maublanc; <i>Phytophthora theobromae</i> L.C. Coleman [Pythiales: Pythiaceae]	Black pod rot of cocoa; fruit rot	Yes	Yes (BAPHIQ, 2004)	Yes (APPD, 2005) Not in WA (DAWA, 2004)	No. Causes root and crown rot of mango and not associated with fruit (Ploetz, 2003); root rot, canker and gummosis of the trunk and branches of several crops including mango (Azzopardi <i>et al.</i> , 2002); root rot of mango (Pernezny & Simone, 2000).	No
<i>Pyricularia leersiae</i> (Sawada) S. Ito [Anamorphic: Magnaporthe]		No	Yes (Matsushima, 1980)	No (APPD, 2005)	No. Recorded as a saprophyte in Taiwan (Matsushima, 1980).	No
<i>Pythium splendens</i> Hans Braun [Pythiales: Pythiaceae]		No	Yes (Chang, 1993)	Yes (APPD, 2005)		No

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		* the Philippines and/or India	Taiwan			
<i>Rhizopus oryzae</i> Went & Prensens Geerlign Syn: <i>Rhizopus arrhizus</i> A. Fisco. [Mucorales: Mucoraceae]	Fruit rot	Yes	Yes (Ho & Chen, 1998)	Yes (APPD, 2005) Not in WA (DAWA, 2003)	Yes. On fruit (Badyal & Sumbali, 1990) but is a post harvest disease.	No
<i>Rosellinia necatrix</i> Berlese ex Prillieux [Xylariales: Xylariaceae]	Dematophthora root rot	No	Yes (CAB International, 2005)	Yes (APPD, 2005)		No
<i>Septobasidium bogoriense</i> Patouillard [Septobasidiales: Septobasidiaceae]		No	Yes (Anon. 1979; Sawada, 1959)	No (APPD, 2005)	No. Occurs on branches and twigs of mango trees in Sarawak, Malaysia (Teo & Kueh, 1984).	No
<i>Stemphylium vesicarium</i> (Wallroth) E.G.Simmons [Anamorphic: Pleospora]	Stemphylium rot	Yes	Yes (Li & Wu, 2002)	Yes (APPD, 2005)		No
<i>Tripospermum myrti</i> (Lind) S. Hughes [Anamorphic: Trichomerium]	Sooty mould	Yes	Yes (Matsushima, 1980)	No (APPD, 2005)	No. Recorded as saprophytic in Taiwan (Matsushima, 1980). This species is a sooty mould on mango fruit (Prakash, 1991), which is considered a cosmetic problem (Nameth <i>et al.</i> , 2003). Sooty mould is easily removed during fruit washing (Laemmlen, 2003).	No
<i>Triposporiopsis spinigera</i> (Höhnelt) W. Yamam. [Capnodiales: Capnodiaceae]		No	Yes (Anon., 1979; Sawada, 1959)	No (APPD, 2005)	No. Occurs on leaves of mango in Taiwan (TFRI, 2005).	No
<i>Verticillium dahliae</i> Klebahn [Anamorphic: Hypomyces]	Wilt	No	Yes (CAB International, 2005)	Yes (APPD, 2005)		No

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		* the Philippines and/or India	Taiwan			
<i>Zygosporium gibbum</i> (Saccardo, M. Rousseau & E. Bommer) S. Hughes [Anamorphic: Ascomycete]		No	Yes (Matsushima, 1980)	Yes (APPD, 2005) Not in WA (DAWA, 2003)	No. Associated with leaves and litter (Nair & Kaul, 1984; Markovskaja & Treigiene, 2004).	No

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APPENDIX 2: POTENTIAL FOR ESTABLISHMENT OR SPREAD AND CONSEQUENCES

Only valid names are used in this table. For lists of synonyms and outdated names please refer to Appendix 1.

Only valid names are used in this table. For lists of synonyms and outdated names please refer to Appendix 1.						
Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for consequences		Consider further?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
ARTHROPODS						
DIPTERA						
<i>Bactrocera cucurbitae</i> (Coquillett, 1899) [Diptera: Tephritidae]	Melon fruit fly	Feasible	Australian climate and host availability provide an environment conducive to the establishment of this species. High egg laying capacity and mobility suggest species can disperse rapidly (CAB International, 2005). Oviposition occurs ~10 days after emergence. Females lay up to 300 eggs in natural conditions (CAB International, 2005).	Significant	<i>Bactrocera cucurbitae</i> is a very serious pest of cucurbit crops throughout its native range (tropical Asia) and in introduced areas such as the Hawaiian Islands. Damage levels can be anything up to 100% of unprotected fruit (CAB International, 2005). Melon flies have more than 80 hosts (CAB International, 2005).	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for consequences		Consider further?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
<i>Bactrocera dorsalis</i> (Hendel, 1912) [Diptera: Tephritidae]	Oriental fruit fly	Feasible	Wide host range (Tsuruta <i>et al.</i> , 1997; Allwood <i>et al.</i> , 1999). Dispersed by infected fruit and adult flight. Strong flyers, adults can fly 50–100 km (Fletcher, 1989). Adults occur throughout the year and can live up to 12 months (CAB International, 2005). A total of 150–200 eggs are laid per female (Srivastava, 1997).	Significant	Primary economic impact would result from quarantine restrictions imposed by important domestic and foreign export markets. Species is a very serious pest of a wide variety of fruits and vegetables, and damage levels can be anything up to 100% of unprotected fruit (CAB International, 2005). In Nauru, before its eradication, <i>B. dorsalis</i> infested up to 95% of mangoes and 90% of guavas (SPC, 2002).	Yes
<i>Bactrocera latifrons</i> (Hendel, 1915) [Diptera: Tephritidae]	Solanum fruit fly	Feasible	Species has a limited host range; however, egg production is not affected by periods of host deprivation (Liquido <i>et al.</i> , 1994). Major hosts are peppers, bell pepper, and black nightshade. Minor hosts are chilli, tomato, currant tomato, cape gooseberry, aubergine, Jerusalem-cherry, turkey berry (CAB International, 2005). Generation time is ~ 20 days. Population clusters have established in marginal arid and windswept areas in Hawaii, where other tephritids have been less successful (Liquido <i>et al.</i> , 1994).	Significant	It was introduced into Hawaii in ~1983 and since then has become established over all major islands of the Hawaiian chain, impacting production of solanaceous and cucurbitaceous crops (Liquido <i>et al.</i> , 1994).	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for consequences		Consider further?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
<i>Bactrocera tau</i> (Walker) [Diptera: Tephritidae]	Fruit fly	Feasible	Infests fruit of susceptible hosts, including mangoes, which are grown in Australia (CAB International, 2005).	Significant	Primary economic impact would result from quarantine restrictions imposed by important domestic and foreign export markets.	Yes
ARTHROPODS						
HEMIPTERA						
<i>Abgrallaspis cyanophylli</i> (Signoret, 1869) [Hemiptera: Diaspididae]	Cyanophyllum scale	Feasible	<i>Abgrallaspis cyanophylli</i> is present in Australia (Donaldson & Tsang, 2002). It is not present in Western Australia (DAWA, 2003).	Significant	Considered to be a serious pest in Israel, USSR and USA (Florida) (Miller & Davidson, 1990).	Yes
<i>Aonidomytilus albus</i> (Cockerell) [Hemiptera: Diaspididae]	Tapioca scale	Feasible	Widely established. Major host is cassava. Minor hosts include papaw, chrysanthemums, mango, sensitive plants and nightshade (CAB International, 2005).	Significant	Can infest a wide range of plant species. Therefore, has potential to cause economic damage if introduced.	Yes
<i>Aulacaspis vitis</i> (Green, 1896) [Hemiptera: Diaspididae]	Armoured scale	Feasible	Cosmopolitan species and no reports of economic impact have been found. Distribution is tropical. Not likely to spread to non-tropical or arid tropical zones (Watson, 2005).	Not significant	Tropical species without a documented history of economic impact on mango or other crops.	No

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for consequences		Consider further?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
<i>Lepidosaphes laterochitinsa</i> Green [Hemiptera: Diaspididae]	Armoured scale	Feasible	Wide host range including mango, citrus, grapevine, and other agricultural and ornamental species (Ben-Dov <i>et al.</i> , 2005). No information available on the biology of this species. Other <i>Lepidosaphes</i> species typically have 1 or 2 generations per year, and females lay up to 100 eggs each during their lifetime (e.g. Xu <i>et al.</i> , 1995; Lin <i>et al.</i> , 1997; Ozgokce <i>et al.</i> , 1999; Song, 2002). Over 20 species of <i>Lepidosaphes</i> are established in Australia (APPD, 2005).	Significant	There is no information available on the economic significance of this species. However, other related species such as <i>Lepidosaphes ulmi</i> , <i>L. pineti</i> and <i>L. beckii</i> are economically significant on fruit crops and forestry plants (Ozgokce <i>et al.</i> , 1999; Smaili <i>et al.</i> , 2000; Song, 2002).	Yes
<i>Milviscutulus mangiferae</i> (Green, 1889) [Hemiptera: Coccidae]	Mango shield scale	Feasible	Polyphagous host range (Ben-Dov <i>et al.</i> , 2005)	Significant	This species can infest a wide range of host plants. Therefore, it has the potential to cause economic damage if introduced.	Yes
<i>Parlatoria pseudaspidotus</i> Lindinger, 1905 [Hemiptera: Diaspididae]	Vanda orchid scale	Feasible	Reported on several species including <i>Mangifera indica</i> (Ben-Dov <i>et al.</i> , 2005). Widely distributed and listed as a pest (Ben-Dov <i>et al.</i> , 2005).	Significant	This species can infest a wide range of host plants. Therefore, it has the potential to cause economic damage if introduced.	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for consequences		Consider further?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
<i>Planococcus lilacinus</i> (Cockerell, 1905) [Hemiptera: Pseudococcidae]	Coffee mealybug	Feasible	Extremely wide host range (Ben Dov <i>et al.</i> , 2005; CAB International, 2005). Susceptible hosts are present in Australia. Most mealybugs have a high reproductive rate (Waite & Hwang, 2002).	Significant	<i>Planococcus lilacinus</i> is a pest of cocoa throughout temperate and southeast Asia and the South Pacific (CAB International, 2005). It also damages a wide variety of economically important crops such as coffee, tamarinds, custard apples, coconuts, citrus, grapes, guavas and mangoes (CAB International, 2005). Therefore, it has potential to cause economic damage if introduced.	Yes
<i>Protopulvinaria pyriformis</i> (Cockerell) [Hemiptera: Coccidae]	Pyriform scale	Feasible	Polyphagous pest attacking many agricultural hosts (Swirski <i>et al.</i> , 1997a). Hosts are present, and the environment is conducive to establishment of this species in Australia. Females can reproduce parthenogenetically (Ben-Dov, 2005).	Significant	Economic importance of the Coccidae mainly results from reduced host vigour due to sap feeding. Appears to be a minor pest of mango (Swirski <i>et al.</i> , 1997b), but the species is reported as a serious pest of fruit trees and ornamentals in several tropical and subtropical countries (Ben-Dov, 1985; De Meijer <i>et al.</i> , 1989; Del Rivero, 1966; Gill, 1988; Hamon & Williams, 1984).	Yes
<i>Pseudococcus cryptus</i> Hempel [Hemiptera: Pseudococcidae]	Citriculus mealybug	Feasible	Wide host range including mango (Ben-Dov, 1994).	Significant	Can infest a wide range of plant species. Therefore, it has potential to cause economic damage if introduced.	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for consequences		Consider further?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
<i>Pseudococcus jackbeardsleyi</i> Gimpel & Miller [Hemiptera: Pseudococcidae]	Jack Beardsley mealybug	Feasible	Reported on mango (Ben-Dov <i>et al.</i> , 2005; CAB International, 2005). Many mealybugs are considered invasive with a history of establishment in new areas (Miller <i>et al.</i> , 2002).	Significant	Reported on a diverse array of fruits, vegetables, and ornamentals from 88 genera in 38 plant families (CAB International, 2005). Mealybugs can directly harm hosts by feeding damage, are reported as disease vectors.	Yes
<i>Pulvinaria taiwana</i> Takahashi [Hemiptera: Coccidae]	Soft scale	Feasible	Reported on <i>Mangifera indica</i> from Taiwan (Ben-Dov <i>et al.</i> , 2005).	Not significant	No significant economic impact documented.	No
<i>Rastrococcus spinosus</i> (Robinson, 1918) [Hemiptera: Pseudococcidae]	Philippine mango mealybug	Feasible	Wide host range and susceptible hosts are present in Australia (Ben-Dov <i>et al.</i> , 2005). On mango, the total development times for males and females are 29 and 35 days respectively (Ullah <i>et al.</i> , 1992).	Significant	<i>Rastrococcus spinosus</i> is a pest of economic significance on mango and citrus in West Africa (Williams, 1986), and on mango in Pakistan (Mahmood <i>et al.</i> , 1983).	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for consequences		Consider further?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
<i>Toxoptera odinae</i> (van der Goot, 1917) [Hemiptera: Aphididae]	Mango aphid	Feasible	Species reproduces asexually, with wingless and winged adult forms aiding dispersal potential. Found seasonally on mango in Malaysia. Reported host range is relatively limited with major hosts being <i>Anacardium</i> , <i>Coffea</i> (coffee), <i>Mangifera indica</i> (mango). Minor hosts are <i>Aralia</i> , <i>Rhododendron</i> (Azalea), <i>Rhus</i> (Sumach), <i>Viburnum</i> (CAB International, 2005; MTFIS, 2005), but these species are present within Australia.	Significant	On economically important plants the aphids mainly cause a minor reduction in fruit yield and timber quality (CAB International, 2005). Certain species of aphids are potential disease vectors.	Yes
<i>Unaspis acuminata</i> (Green) [Hemiptera: Diaspididae]	Unaspis scale	Feasible	Host range includes mango, citrus species, and <i>Ficus</i> species amongst others (Ben-Dov <i>et al.</i> , 2005). No information available on the biology of this species. Other species of this genus have 2 or 3 generations per year and overwinter as adult females (Gill, 1997). <i>Unaspis citri</i> is established in Australia (APPD, 2005).	Significant	Although there is no information available on the economic significance of this species, other species in this genus have a high impact on their hosts. For example, <i>U. euonymi</i> can cause death of euonymus plants in California (Gill, 1997), and <i>U. citri</i> is a major pest of citrus plants in the South Pacific (Williams & Watson, 1988).	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for consequences		Consider further?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
LEPIDOPTERA						
<i>Orgyia australis postica</i> (Walker, 1855) Regarded by some authors to be <i>Orgyia postica</i> Recorded as <i>Notolophorus australis posticus</i> Walker [sic] in BAPHIQ (2004) [Lepidoptera: Lymantriidae]	Cocoa tussock moth	Feasible	<i>Orgyia australis postica</i> is a forest species which has adapted well to orchards and forest plantations (CAB International, 2005). Susceptible hosts are present in Australia. Host range includes widely cultivated plants such as mango, pear, grapevine and tea (CAB International, 2005). Optimum development for <i>O. australis postica</i> is 25°C; at this temperature the life-cycle takes 33 days. Females have been recorded laying up to 500 eggs each (Cheng <i>et al.</i> , 2001).	Significant	In Taiwan, <i>O. postica</i> is a major pest of cultivated grapevines (Chang, 1988) and roses (Wang, 1982). Larvae cause serious damage to young leaves of cacao in the Philippines, both in nurseries and plantations (Sanchez & Laigo, 1968; CAB International, 2005). When very numerous they can cause total defoliation, killing or stunting of the tree (Sanchez & Laigo, 1968). The species is recorded as an economically significant pest of mango in India (Gupta & Singh, 1986), and of soyabeans, mungbeans and red beans in Taiwan (Su, 1987). Reported to be of minor importance by BAPHIQ (2004).	Yes

Scientific name	Common name	Potential for establishment and spread in the PRA area		Potential for consequences		Consider further?
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
THYSANOPETRA (thrips)						
<i>Rhipiphorothrips cruentatus</i> Hood, 1919 [Thysanoptera: Thripidae]	Mango thrips	Feasible	Host range includes mango, guava, grapevine, pomegranate, cashew and sugarapple (CAB International, 2005). Both sexual reproduction and parthenogenesis is known for this species. Females lay about 13 eggs each on wax apple in Taiwan (Chiu, 1984).	Significant	<i>Rhipiphorothrips cruentatus</i> is one of the most important pests of grapevine in India (Rahman & Bhardwaj, 1937). In Taiwan, wax apple has been severely attacked (Chiu, 1984), and other crops such as mango and guava have also been damaged (Chang, 1995).	Yes
FUNGI						
<i>Elsinoë mangiferae</i> Bitancourt & Jenkins [Myriangiales: Elsinoaceae]	Mango scab	Feasible	Establishment and spread is limited as mango is the only reported host. Dispersal of conidia is via rain and wind and germination is reliant on free water (Bitancourt & Jenkins, 1943, 1946; CAB International, 2005). Mature fruit is resilient to attack.	Significant	There are no reports of <i>E. mangiferae</i> infecting plants other than mango. However, losses from the disease can be relatively high if uncontrolled. Established in Australia (Northern Territory and Queensland) (CAB International, 2005), but Western Australia has area freedom.	Yes

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APPENDIX 3: DATA SHEETS FOR QUARANTINE PESTS

Fruit flies

Bactrocera cucurbitae (Coquillett) [Diptera: Tephritidae] – melon fly

Bactrocera dorsalis (Hendel) [Diptera: Tephritidae] – Oriental fruit fly

Bactrocera latifrons (Hendel) [Diptera: Tephritidae] – solanum fruit fly

Bactrocera tau (Walker) [Diptera: Tephritidae] – fruit fly.

Due to the cosmopolitan economic importance of *Bactrocera dorsalis*, this species is used as the basis for the datasheet for all aforementioned fruit fly species.

Synonyms and changes in combination:

Bactrocera cucurbitae: *Dacus cucurbitae* Coquillett; *Dacus yuiliensis* Tseng and Chu; *Dacus aureus* Tseng and Chu.

Bactrocera dorsalis: *Dacus dorsalis* Hendel, 1912; *Bactrocera conformis* Doleschall, 1858 (preocc.); *Bactrocera ferrugineus* (Fabricius); *Chaetodacus dorsalis* (Hendel); *Chaetodacus ferrugineus* (Fabricius); *Chaetodacus ferrugineus dorsalis* (Hendel); *Chaetodacus ferrugineus okinawanus* Shiraki, 1933; *Dacus ferrugineus* Fabricius; *Dacus ferrugineus dorsalis* Fabricius; *Dacus ferrugineus* var. *dorsalis* Fabricius; *Dacus ferrugineus okinawanus* (Shiraki); *Musca ferruginea* Fabricius (preocc.); *Musca ferruginea* Fabricius, 1794; *Strumeta dorsalis* (Hendel); *Chaetodacus ferrugineus* (Fabricius); *Strumeta ferrugineus* (Fabricius).

Bactrocera latifrons: *Bactrocera* (*Bactrocera*) *latifrons* (Hendel); *Chaetodacus antennalis* Hendel; *Chaetodacus latifrons* Hendel; *Dacus latifrons* Hendel; *Dacus parvulus* Hendel.

Bactrocera tau: *Dacus tau* Walker; *Bactrocera hageni* (Hendel); *Bactrocera* (*Zeugodacus*) *tau* (Walker); *Dacus hageni* (de Meijere); *Chaetodacus tau* (Walker); *Dacus caudatus* var. *nubilus* (Hendel); *Dacus nubilus* (Hendel); *Dasyneura tau* (Walker); *Zeugodacus nubilus* (Hendel).

Hosts:

Bactrocera cucurbitae: This species is a very serious pest of cucurbit crops (CAB International, 2005). Primary hosts are species of Cucurbitaceae, as follows: *Cucumis melo* (melon) (Drew, 1982; Allwood *et al.*, 1999), *Cucurbita maxima* (giant pumpkin) (Tsuruta *et al.*, 1997; Allwood *et al.*, 1999), *Cucurbita pepo* (ornamental gourd) (Drew, 1982; Allwood *et al.*, 1999) and *Trichosanthes cucumerina* (snake gourd) (Tsuruta *et al.*, 1997; Allwood *et al.*, 1999).

Other hosts include: *Abelmoschus moschatus*, *Artocarpus heterophyllus* (jackfruit), *Benincasa hispida* (wax gourd), *Carica papaya* (papaw), *Citrullus colocynthis* (colocynth), *Citrullus lanatus* (watermelon), *Citrus hystrix*, *Citrus maxima* (pummelo), *Citrus sinensis* (navel orange), *Cucumis auguria* (gerkin), *Cucumis sativus* (cucumber), *Cucurbita moschata* (pumpkin), *Cydonia oblonga* (quince), *Cyphomandra betacea* (tree tomato), *Ficus carica* (fig), *Lagenaria siceraria* (bottle gourd), *Luffa acutangula* (angled luffa), *Luffa aegyptiaca* (loofah), *Lycopersicon esculentum* (tomato), *Mangifera indica* (mango), *Manilkara zapota* (sapodilla), *Momordica balsamina* (common balsamapple), *Momordica charantia* (bitter gourd), *Passiflora edulis* (passionfruit), *Persea americana* (avocado), *Phaseolus vulgaris* (common bean), *Prunus persica* (peach), *Psidium guajava* (guava), *Sechium edule*, *Sesbania grandiflora* (agati), *Syzygium samarangense* (water apple), *Trichosanthes cucumerina* var. *anguinea* (snakegourd), *Vigna unguiculata* (cowpea), *Ziziphus jujuba* (common jujube) (CAB International, 2005).

Bactrocera dorsalis: This species is a very serious pest of a wide variety of fruits and vegetables (CAB International, 2005). Due to the confusion between *B. dorsalis* and related species in the Oriental fruit fly species complex (some 52 species that are found in the Oriental region, and a further 16 species native to Australasia), there are very few published host records which definitely refer to true *B. dorsalis* (CAB International, 2005). No host plant survey has yet been carried out to show which hosts are of particular importance within the Asian range of true *B. dorsalis*.

Recorded commercial hosts are: *Aegle marmelos* (bael fruit), *Anacardium occidentale* (cashew), *Annona reticulata* (bullock's heart), *A. squamosa* (sugar apple), *Areca catechu* (betelnut palm), *Artocarpus altilis* (breadfruit), *A. heterophyllus* (jackfruit), *Capsicum annuum* (bell pepper), *Chrysophyllum cainito* (caimito), *Citrus maxima* (pummelo), *C. reticulata* (mandarin orange), *Coffea arabica* (arabica coffee), *Cucumis melo* (melon), *C. sativus* (cucumber), *Dimocarpus longan* (longan), *Ficus racemosa* (cluster fig), *Litchi chinensis* (lychee), *Malus pumila* (apple), *Mangifera foetida* (bachang mango), *M. indica* (mango), *Manilkara zapota* (sapodilla), *Mimusops elengi* (Asian bulletwood), *Momordica charantia* (bitter gourd), *Muntingia calabura* (Jamaica cherry), *Musa* sp. (banana), *Nephelium lappaceum* (rambutan), *Persea americana* (avocado), *Prunus armeniaca* (apricot), *P. avium* (gean), *P. cerasus* (sour cherry), *P. domestica* (plum, prune), *P. mume* (Japanese apricot), *P. persica* (peach), *Psidium guajava* (guava), *Punica granatum* (pomegranate), *Pyrus communis* (pear), *Syzygium aqueum* (water apple), *S. aromaticum* (clove), *S. cumini* (jambolan), *S. jambos* (rose apple), *S. malaccense* (Malay apple), *S. samarangense* (wax apple), *Terminalia catappa* (Indian almond), *Ziziphus jujuba* (jujube); *Z. mauritiana* (Chinese date) (Tsuruta *et al.*, 1997; Allwood *et al.*, 1999).

Bactrocera latrifrons: In Taiwan, this species has been reported from *Litchi chinensis*, *Lycopersicon pimpinellifolium*, *Solanum* sp. *Solanum incanum*, *Solanum indicum* and *Ziziphus jujube* (Liquido *et al.*, 1994). It has also been recorded attacking mango in

Thailand (Karnkowski *et al.*, 2003) and Malaysia (Liquido *et al.*, 1994). It is principally a pest of solanaceous and cucurbitaceous crops in Hawaii (Liquido *et al.*, 1994).

Bactrocera tau: This species appears to show a preference for attacking the fruits of Cucurbitaceae, but it has also been reared from the fruits of several other plant families (CAB International, 2005). Due to the recent separation of previously confused species, the host data given below were taken from a recently published host catalogue that was largely based on a 1990s survey carried out in Thailand and Malaysia (Allwood *et al.*, 1999).

Hosts include: *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Cucurbita maxima* (giant pumpkin), *Luffa acutangula* (angled luffa), *Momordica charantia* (balsam apple) (CAB International, 2005); *Mangifera indica* (mango) (Peña and Mohyuddin, 1997).

Plant part(s) affected:

Fruit (Peña and Mohyuddin, 1997; Srivastava, 1997; CAB International, 2005).

Distribution:

Bactrocera cucurbitae: The native range of this species includes most of Asia. It was introduced to Hawaii in the late 19th century (Clausen, 1978). Apart from Asia, CAB International (2005) includes the following countries in its distribution: in Africa this species is found in Cameroon, Côte d'Ivoire, Egypt, Gambia, Guinea, Kenya, Mali, Mauritius, Réunion, Seychelles, Somalia and Tanzania. In the USA, this species occurs in Hawaii and in Oceania it is known from Guam, Kiribati, Nauru, Northern Mariana Islands, Papua New Guinea, Bougainville and the Solomon Islands.

Bactrocera dorsalis: True *B. dorsalis* is restricted to mainland Asia (except the peninsula of southern Thailand and West Malaysia), as well as Taiwan and its adventive population in Hawaii (Drew and Hancock, 1994). CAB International (2005) also includes California and Florida, USA, in the distribution because the fly is repeatedly trapped there in small numbers. This species is a serious pest of a wide range of fruit crops in Taiwan, southern Japan, China and northern areas of the Indian subcontinent (CAB International, 2005).

In Asia, *B. dorsalis* is recorded from Bangladesh (IIE, 1994); Bhutan, Cambodia, China (Drew and Hancock, 1994); Guam (Waterhouse, 1993); Laos, Myanmar (Drew and Hancock, 1994); Nauru (Waterhouse, 1993); Nepal, Pakistan, Sri Lanka, Thailand, United States (Hawaii) and Vietnam (Drew and Hancock, 1994).

Bactrocera latifrons: This species is native to South and Southeast Asia and has also been recorded in China, India, Laos, Malaysia, Pakistan, Sri Lanka, Taiwan and Thailand. In the early 1980s it was introduced to Hawaii where it has since established on all major islands in the Hawaiian chain (Liquido *et al.*, 1994).

Bactrocera tau: Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Singapore, Taiwan, Thailand, Viet Nam (CAB International, 2005).

Biology: The eggs of *Bactrocera oleae* were described in detail by Margaritis (1985) and those of other species are similar. They are 0.8 mm long, 0.2 mm wide, and white to yellow-white in colour (Margaritis, 1985). Females lay a number of eggs per fruit. Clutch sizes of 3–30 eggs have been recorded for *B. dorsalis* (Fletcher, 1989). Eggs of *B. dorsalis* are laid below the skin of the host fruit. These hatch within a day (although this can be delayed up to 20 days in cool conditions) and the larvae feed for another 6–35 days, depending on the season. Eggs are visible to the naked eye (CAB International, 2005). Third instar larva of *B. dorsalis* are medium-sized, 7.5–10.0 mm long and 1.5–2.0 mm wide (White and Elson-Harris, 1994).

Pupation occurs in the soil under the host plant for 10–12 days but may be delayed for up to 90 days under cool conditions (Christenson and Foote, 1960). Pupae are barrel-shaped with most larval features unrecognisable. Puparium are usually 60–80% length of larva. Pupae can be found in the growing medium, accompanying plants, and are also visible to the naked eye, being white to yellow-brown in colour. Plant parts other than fruit are not known to carry the pest in trade and or transport (CAB International, 2005). Fruits and growing media are liable to carry pupae of this fruit fly in trade and or transport (CAB International, 2005).

Adults are predominantly black or dark fuscous, or a balanced mixture of black and yellow. When the thorax is viewed dorsally, there are a number of pale whitish to yellow lateral stripes over the anterior plates. In addition, the posterior thoracic plates are black with orange to red-brown areas, or black. The abdomen is oval or parallel sided with a mediolateral dark stripe running most of its length (Carrol *et al.*, 2002). Adults occur throughout the year and begin mating after 8–12 days, and may live 1–3 months depending on temperature—up to 12 months in cool conditions (Christenson and Foote, 1960). Adults may live for many months and in laboratory studies, the potential fecundity of female *B. dorsalis* is over 1000 eggs (Fletcher, 1989).

The major means of movement and dispersal are transportation of infected fruit and adult flight (Fletcher, 1989). Many *Bactrocera* species can fly 50–100 km (Fletcher, 1989).

Little information is available on the attack time for most fruits but few *Bactrocera* species attack prior to ripening (CAB International, 2005). Fruit show the following symptoms of infestation: some necrosis around the puncture mark—‘sting’—following oviposition, which causes decomposition of the fruit that appears as black or brown lesions. Premature fruit-drop from trees can occur (CAB International, 2005).

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Armoured scales

Abgrallaspis cyanophylli Signoret, 1869 [Hemiptera: Diaspididae] – Cyanophyllum scale, red scale

Aonidomytilus albus Cockerell [Hemiptera: Diaspididae] – Tapioca scale

Lepidosaphes laterochitinosus Green [Hemiptera: Diaspididae]

Parlatoria pseudaspidotus Lindinger, 1905 [Hemiptera: Diaspididae] – Vanda orchid scale

Unaspis acuminata Green [Hemiptera: Diaspididae] – Unaspis scale

Synonyms and changes in combination:

Abgrallaspis cyanophylli: *Aspidiotus cyanophylli* Signoret, 1869; *Fucaspis cyanophylli* Signoret; *Hemiberlesia cyanophylli* Signoret.

Aonidomytilus albus: *Mytilaspis albus* Cockerell; *Mytilaspis albus* Cockerell; *Mytilaspis alba*; Cockerell; *Coccomytilus albus* Leonardi; *Lepidosaphes alba* Fernald; *Mytilaspis coccomytilus dispar* Vayssi re; *Mytilaspis (Coccomytilus) dispar* Vayssi re; *Lepidosaphes dispar* S sser; *Coccomytilus dispar* Takahashi; *Aonidomytilus albus* Ferris; *Mytilococcus albus* Lindinger; *Lepidosaphes (Aonidomytilus) albus* Merrill.

Lepidosaphes laterochitinosus: *Lepidosaphes bladhiae* Takahashi, 1931; *Parainsulaspis bladhiae* Borchsenius, 1963; *Parainsulaspis laterochitinosus* Borchsenius, 1963; *Lepidosaphes spinulosa* Beardsley, 1966.

Parlatoria pseudaspidotus: *Parlatoria mangiferae* Marlatt; *Parlatorea mangiferae* Lindinger; *Leucaspis mangiferae* Wester; *Genaparlatoria mangiferae* MacGillivray; *Genaparlatoria pseudaspidotus* MacGillivray; *Aonidia pseudaspidotus* Cockerell; *Parlatoria pseudaspidotus* Ferris; *Parlatoria (Genaparlatoria) pseudaspidotus* Merrill; *Pinnaspis pseudaspidotus* Reyne.

Unaspis acuminata: *Chionaspis acuminata* Green; *Unaspis acuminata* MacGillivray.

Hosts:

Abgrallaspis cyanophylli: *Acalypha hispida* (chenille plant), *Annona squamosa* (sugar apple), *Annona* sp. (custard apple), *Artocarpus altilis* (breadfruit), *Bauhinia* sp., *Barringtonia* sp., *Camellia sinensis* (tea), *Capsicum ovatum*, *Ceiba pentandra* (kapok tree), *Cinnamomum verum* (cinnamon), *Clerodendrum* sp., *Coccoloba uvifera* (Jamaican kino, sea-grape), *Cocos nucifera* (coconut), *Coffea arabica* (arabica coffee), *Coffea* sp. (coffee), *Coleus* sp., *Cordyline fruticosa* (palm lily), *Dioscorea alata* (greater yam), *Dioscorea* spp. (yam), *Elettaria cardamomum* (cardamom), *Eriobotrya japonica* (loquat), *Eugenia* sp., *Ficus* sp. (fig), *Guettarda speciosa* (beach gardenia), *Hevea brasiliensis*

(rubber tree), *Hibiscus syriacus* (rose-of-Sharon), *Jatropha curcas* (Barbados-nut), *Macadamia tetraphylla* (rough-shell Queensland nut), *Mangifera indica* (mango), *Manihot esculenta* (cassava), *Musa × paradisiaca* (banana), *Musa* sp. (banana), *Persea americana* (avocado), *Piper methysticum* (kava kava), *Plumeria rubra* f. *acutifolia* (Mexican frangipani), *Psidium guajava* (guava), *Swietenia macrophylla* (Honduras mahogany), *Theobroma cacao* (cocoa), *Toona ciliata* (Australian red cedar) (Williams and Watson, 1988); *Nerium* sp. (oleander) (CAB International, 2005).

Aonidomytilus albus: *Atriplex* sp., *Carica papaya* (papaya), *Chrysanthemum* sp., *Croton bonplandianus*, *Flourensia*, *Harrisia*, *Jatropha gossypifolia*, *Jatropha* sp., *Malvastrum americanum*, *Mangifera indica* (mango), *Manihot aipi*, *Manihot esculenta*, *Manihot utilissima*, *Mimosa* sp., *Salvia* sp., *Sechium* sp., *Sida carpinifolia*, *Solanum melongena*, *Solanum* sp., *Solanum torvum*, *Suaeda*, *Turnera ulmifolia* (Ben-Dov et al., 2005).

Lepidosaphes laterochitinos: *Agalma lutchuense*, *Alstonia scholaris*, *Ardisia crenata*, *Ardisia japonica*, *Ardisia sieboldii*, *Ardisia* sp., *Areca catechu*, *Artocarpus communis* (breadfruit), *Asparagus* sp., *Barringtonia asiatica*, *Bladhia sieboldi*, *Bladhia* sp., *Bruguiera hexangula*, *Bruguiera* sp., *Camellia sinensis* (tea), *Castanea* sp., *Casuarina* sp., *Cestrum* sp., *Citrus* sp., *Cocos nucifera* (coconut), *Coelogyne* sp., *Cycas circinalis seemanii*, *Cycas circinalis*, *Cycas* sp., *Epipremnum mirabile*, *Eurya japonica*, *Eurya* sp., *Garcinia* sp., *Glochidion* sp., *Heptapleurum octophyllum*, *Heterosmilax japonica*, *Hevea* sp., *Hyophorbe verschaffeltii*, *Illicium anisatum*, *Illicium philippinense*, *Machilus kusanoi*, *Maesa* sp., *Mangifera indica* (mango), *Manihot esculenta*, *Osmanthus fragrans*, *Plumeria acuminata*, *Psidium* sp., *Ravenala* sp., *Rhizophora mucronata*, *Schefflera octophylla*, *Smilax china*, *Smilax glabra*, *Smilax* sp., *Ternstroemia gymnanthera*, *Vitis* sp., *Vitis vinifera* (grapevine) (Ben-Dov et al., 2005).

Parlatoria pseudaspidiotus: *Aerides* sp., *Caryopteris incana*, *Cattleya* sp., *Commiphora berryi*, *Cymbidium* sp., *Cyrtopodium punctatum*, *Dendrobium* sp., *Euphorbia antiquorum*, *Mangifera indica* (mango), *Trichoglottis philippinensis*, *Vanda hookeriana*, *Vanda jaquiem*, *Vanda* sp., *Vanda teres* (Ben-Dov et al., 2005).

Unaspis acuminata: *Ardisia* sp., *Bassia latifolia*, *Bassia* sp., *Carissa* sp., *Citrus* sp., *Cycas revoluta*, *Dipterocarpus*, *Euonymus resoluta*, *Euonymus*, *Evodia* sp., *Picus*, *Leea* sp., *Mangifera indica* (mango), *Morinda*, *Severinia buxifolia*, *Turpinia formosana* (Ben-Dov et al., 2005).

Plant part(s) affected: For the listed armoured scales, the plant parts affected include leaves, stems and fruit (Srivastava, 1997; CAB International, 2005).

Distribution:

Abgrallaspis cyanophylli: Cook Islands, Fiji, French Polynesia (Williams and Watson, 1988); Georgia, India (CAB International, 2005); Kiribati, New Caledonia, Papua New

Guinea, Tonga, Tuvalu, Vanuatu, Western Samoa (Williams and Watson, 1988). This species has also been recorded in Australia (New South Wales, Queensland, Tasmania), but not in Western Australia (AICN, 2004).

Aonidomytilus albus: Angola, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Brazil, British Virgin Islands, China, Colombia, Cuba, Dominica, Dominican Republic, French Guiana, Ghana, Grenada, Guadeloupe, Guyana, Haiti, Hong Kong, India, Jamaica, Kenya, Madagascar, Malawi, Malaysia, Martinique, Mauritius, Mexico, Mexico, Montserrat, Mozambique, Nigeria, Puerto Rico and Vieques Island, Saint Croix, Saint Kitts and Nevis Islands, Saint Lucia, Saint Vincent and the Grenadines, Somalia, Sri Lanka, Taiwan Tanzania, Trinidad and Tobago, U.S. Virgin Islands, Uganda, United States of America (Ben-Dov *et al.*, 2005).

Lepidosaphes laterochitinsa: China, Guam, Japan, Malaysia, Northern Mariana Islands, Palau, Philippines, Ponape Island, Taiwan, United Kingdom Wake Island (Ben-Dov *et al.*, 2005).

Parlatoria pseudaspidotus:

Barbados, Bonin Islands, Cameroon, China, Colombia, Costa Rica, Fiji, Germany, Guam, Guyana, Hawaiian Islands, India, Indonesia, Italy, Jamaica, Japan, Malaysia, Myanmar, Pakistan, Panama, Papua New Guinea, Philippines, Puerto Rico and Vieques Island, Singapore, South Africa, Sri Lanka, Sudan, Suriname, Tahiti, Taiwan, Thailand, Trinidad and Tobago, United Kingdom, United States of America, Vietnam, Western Samoa (Ben-Dov *et al.*, 2005).

Unaspis acuminata: China, India, Sri Lanka, Taiwan, Thailand (Ben-Dov *et al.*, 2005).

Biology: Diaspidids are strongly sexually dimorphic. Diaspididae reproduction is usually sexual but parthenogenesis may occur in some species (Rosen, 1990); relatively few species are oviparous, most being ovoviviparous or viviparous (Koteja, 1990a). There are two immature instars in the female, which has no pupal stage. The male has 2 feeding larval instars followed by two non-feeding stages (pre-pupa and pupa) before a winged adult emerges (Koteja, 1990b).

Diaspidids display division of function between different developmental stages within their life cycle. The first instar crawler developmental stage is the dispersive stage, with the role of locating a suitable feeding site; aiding this process they may travel to the top of a plant and spread their legs for wind dispersal. Crawlers may be dispersed on birds' feet, insects, animals or man (directly or indirectly via transport on infected plant materials). Moderate to high humidity, without precipitation, favours crawler survival (Watson, 2005).

Crawlers locating a suitable feeding site will settle, feed and moult to form the second instar. The second instar larvae are sessile, lacking legs and are the main feeding stage.

Subsequently the second instar female moults to the sessile adult stage, with feeding and reproduction roles. In sexual reproduction, adult females mate soon after the last moult. In viviparous and ovoviviparous species feeding continues during the reproductive period which may occur over several weeks or months. In contrast some oviparous species stop feeding before the short period of oviposition begins (Koteja, 1990b). Male development continues, beyond the second instar, under the protective scale cover produced by the second instar (the final feeding stage for the male). The second instar moults into a prepupa with small wing buds, which moults into a pupa (with larger wing buds), and finally the pupa moults into a functional winged adult male, which rests beneath the scale cover before emerging to seek a mate. Adult males lack mouthparts for feeding and they are short-lived. The sex ratio in diaspidid scale insects is usually about 1:1, but there are examples of strongly biased ratios that may be due to environmental conditions or a population structure that favours inbreeding, or due to maternal age (Watson, 2005).

Most species produce 50–150 eggs per female (but some produce as few as 10 or as many as 600), at a rate of 1–10 laid per day, according to species and conditions. Eggs are laid under the protective scale cover, from which the crawlers later disperse.

Diaspididae do not excrete honeydew. They are therefore neither associated with sooty mould growths, nor are they normally attended by ants. Any sooty mould or ants in the vicinity are associated with other honeydew-excreting insects nearby, e.g. Pseudococcidae, Coccidae or Margarodidae.

The armoured scales *Abgrallaspis cyanophylli*, *Aonidomytilus albus* are both listed as significant economic pest in Miller and Davidson (1990).

Abgrallaspis cyanophylli: The cyanophyllum scale is widely distributed in the tropical and subtropical regions. It is polyphagous causing damage to various ornamentals (Davidson and Miller, 1990), as well as horticultural crop plants (CAB International, 2005).

Abgrallaspis cyanophylli has been reported to cause damage on avocado trees in Israel (Gerson and Zor, 1973), guava in Fiji (Lever, 1945) and tea in Papua New Guinea (Williams and Watson, 1988).

In northern Taiwan *A. cyanophylli* is one of the most important pests of tea (Shiao, 1979). A single female may lay up to 60 eggs with a 93% hatch rate and five overlapping generations per year (Shiao, 1979). In laboratory studies the survival rate at 25°C was 75.9% and at 30°C it was only 44.7% (He *et al.*, 1998). The nymphal stage varied from 37.0 to 64.5 days between 20 and 28°C. The number of crawler offspring per female was greatest at 28°C, and the optimal survival rate occurred at 75% humidity (He *et al.*, 1998). Population size may be influenced by temperature, rainfall, a parasites and pathogens (Shiao, 1979). *Abgrallaspis cyanophylli* has been the subject of several biological control studies (Gaprindashvili, 1975; Ponsonby and Copland, 1995; 2000).

Aonidomytilus albus: The species is considered to have spread from the New World with the dissemination of cassava planting sticks (CAB International, 2005). *Aonidomytilus albus* is a serious pest of cassava in East and West Africa, Argentina, Brazil, Colombia, India, Madagascar, Mexico, Taiwan, Thailand, West Indies and USA (Bellotti, 1978; Miller and Davidson, 1990; CAB International, 2005).

First instars walk or are carried by wind to new feeding sites (CAB International, 2005). Dry conditions increase plant susceptibility to attack and favour the dissemination of crawlers which may drown or be swept off the host in wet conditions (CAB International, 2005). Females begin to lay eggs about two days after reaching maturity (Anantanarayanan *et al.*, 1957). Eggs hatch after 3–4 days and develop into mature adults over a period of 20–25 days (Lal and Pillai, 1981).

New infections are predominantly initiated by the first instar crawler which typically spreads downwind to plants in close proximity. This stage is short-lived, especially in the absence of a host. Dispersal over longer distances requires human or animal assistance (CAB International, 2005).

*Lepidosaphes laterochitinos*a: The biology and ecology of this species have not been reported. The natural enemies of this species have not been studied, further limiting assessment of its capacity for economic and environmental impact if introduced. However, species within the genus *Lepidosaphes* are identified as pests of significant economic significance. For example, *L. beckii* is a polyphagous species that has been recorded from hosts belonging to 45 genera in 11 plant families (Davidson and Miller, 1990), and its host range may well be wider. *Lepidosaphes beckii* is one of the most important pests of *Citrus* wherever it is grown (Williams and Watson, 1988).

Parlatoria pseudaspidiotus: This species is reported as a pest of *Mangifera indica* (Ben-Dov *et al.*, 2005). Balachowsky (1953) described *P. pseudoaspidiotus* as damaging on orchids cultivated under glass; introduction might threaten orchid production. However, Miller and Davidson (1990) considered it a non-serious pest in a global compilation of economically significant armoured scale pests. The natural enemies of this species have not been studied, further limiting assessment of its capacity for economic and environmental impact if introduced.

The biology and ecology of this species have not been extensively reported. Generally, crawlers are the primary dispersal stage for armoured scales as is dispersal by wind or animal contact. However, mortality due to abiotic factors is high in this stage. Sessile adults and eggs may be dispersed through human transport of infested plant material.

Unaspis acuminata: The biology and ecology of this species have not been reported. The natural enemies of this species have not been studied, further limiting assessment of its capacity for economic and environmental impact if introduced. However, species within

the genus *Unaspis* are identified as pests of significant economic significance. For example, the polyphagous *Unaspis citri*, attacks plant species belonging to 9 genera in 7 plant families (Davidson and Miller, 1990), including *Citrus* spp. *Unaspis yanonensis* is the most important pest of *Citrus* in Japan (Rosen, 1990), and Foldi, (2001) lists it as of economic importance causing widespread damage to *Citrus* in the French Riviera.

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Soft scales

Protopulvinaria pyriformis (Cockerell, 1905) [Hemiptera: Coccidae] - Pyriform scale

Milviscutulus mangiferae (Green, 1889) [Hemiptera: Coccidae] - Mango shield scale

Synonyms and changes in combination:

Protopulvinaria pyriformis: *Pulvinaria* (*Protopulvinaria*) *pyriformis* Cockerell, 1894;

Protopulvinaria pyriformis Cockerell, 1894; *Pulvinaria newsteadi* Leonardi, 1898;

Pulvinaria plana Lindinger, 1911; *Protopulvinaria piriformis* Lindinger, 1912;

Protopulvinaria piriformis Brain, 1920; *Protopulvinaria piriformes* Gomez-Menor Ortega, 1929; *Protopulvinaria agalmae* Takahashi, 1933; *Protopulvinaria pyiformis* Tao, 1978;

Pulvinaria phriformis Pollard & Alleyne, 1986.

Milviscutulus mangiferae: *Lecanium mangiferae* Green, 1889; *Coccus mangiferae* (Green);

Lecanium psidii Green, 1904; *Saissetia psidii* (Green); *Lecanium wardi* Newstead, 1922;

Coccus wardi (Newstead); *Lecanium desolatum* Green, 1922; *Lecanium ixorae* Green, 1922;

Protopulvinaria mangiferae (Green); *Coccus ixorae* (Green); *Coccus kuraruensis* Takahashi, 1939; *Protopulvinaria ixorae* (Green); *Coccus desolatum* (Green); *Kilifia mangiferae* (Green);

Udinia psidii (Green).

Hosts:

Protopulvinaria pyriformis: *Adhatoda vasica*, *Agalma lutchuense*, *Altidesma buniis*, *Amomis*, *Antidesma buniis*, *Apollonias barbuja*, *Aralia*, *Araujia sericifera*, *Bauhinia chamioni*, *Bauhinia vahlii*, *Brassaia actinophylla*, *Canna indica*, *Caprifolium*, *Carica papaya* (papaya), *Carissa grandiflora*, *Choisya ternata*, *Cinnamomum camphora* (caphor laurel), *Cinnamomum cassia*, *Cinnamomum zeylanicum*, *Citrus aurantium* (bitter orange), *Clerodendrum*, *Cymbidium*, *Diospyros erianthi*, *Dizygotheca*, *Dracaena durante*, *Elaeocarpus elliptica*, *Elaeocarpus serratus*, *Epidendrum*, *Eucalyptus*, *Eugenia jambolana*, *Fatsia japonica*, *Ficus*, *Hedera canariensis*, *Hedera helix* (holly), *Hibiscus sinensis*, *Gardenia fortunei*, *Gardenia jasminoides*, *Ilex canariensis*, *Ilex perado*, , *Ipomoea*, *Lagerstroemia indica*, *Laurus azorica*, *Laurus canariensis*, *Laurus nobilis*, *Lonicera etrusca*, *Malpighia glabra*, *Mangifera indica* (mango), *Musa cavendishi*, *Myrica* spp., *Myricaria*, *Myrtus communis*, *Nerium*, *Ocotea foetens*, *Passiflora*, *Peltophyllum peltatum*, *Persea americana* (avocado), *Persea borbonia*, *Persea gratissima*, *Pittosporum tobira*, *Plumeria tricolor*, *Psidium guajava* (guava), *Punica*, *Schefflera octophylla*, *Tetrapanax papyriferum*, *Trachelospermum jasminoides*, *Veronica*, *Viburnum tinus* (Ben-Dov, et al., 2005).

Milviscutulus mangiferae: *Alstonia spectabilis*, *Ananas*, *Artocarpus altilis*, *Artocarpus heterophyllus*, *Artocarpus integra*, *Artocarpus integrifolia*, *Bischofia javanica*, *Bixa orellana*, *Blighia sapida*, *Breynia cernua*, *Brunfelsia nitida*, *Camptosperma brevipetiolata*, *Caladium*, *Carica papaya* (papaya), *Champereia manillana*, *Cinnamomum cassia*, *Cinnamomum*

zeylanica, *Citrus limon* (lemon), *Citrus sinensis* (orange), *Cocos nucifera* (coconut), *Codiaeum variegatum*, *Cordia myxa*, *Cordyline fruticosa*, *Cordyline terminalis*, *Decaspermum*, *Dendrobium spectabile*, *Elaeocarpus*, *Epipremnum*, *Eucalyptus citriodora*, *Eucalyptus deglupta*, *Eugenia aquea*, *Eugenia axillaris*, *Eugenia caryophyllata*, *Eugenia jambolona*, *Eugenia jambos*, *Eugenia malaccensis*, *Eugenia parkeri*, *Ficus gibbosa*, *Ficus glandulifera*, *Ficus septica*, *Ficus theophrastoides*, *Ficus tinctoria*, *Flagellaria*, *Gardenia florida*, *Gliricidia*, *Gluta turtur*, *Gnetum gnemon*, *Guioa*, *Gymnacranthera*, *Gynotroches axilaris*, *Hibiscus*, *Ixora coccinea*, *Jambosa*, *Jasminum trifoliatum*, *Litsea zeylanica*, *Malpighia glabra*, *Mangifera indica* (mango), *Merremia*, *Meryta macrophylla*, *Monstera deliciosa*, *Morinda citrifolia*, *Myristica moschate*, *Palaquium formosanum*, *Parathesis cubana*, *Persea americana* (avocado), *Pimelodendron amboinicum*, *Platanocephalus chinensis*, *Platanocephalus morindaefolius*, *Plumeria*, *Pometia pinnata*, *Pseudolmedia havanensis*, *Psidium friedrichsthalianum*, *Psidium guajava* (guava), *Psychotria elyptica*, *Psychotria rubra*, *Rapanea quianensis*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhodomirtus tomentosa*, *Schefflera*, *Strelitzia*, *Terminalia brassii*, *Terminalia catappa*, *Terminalia complanata*, *Timonius*, *Thevetia peruviana*, *Uvaria rufa*, *Vanilla*, *Vitex pubescens*, *Wedelia biflora* (Ben-Dov *et al.*, 2005).

Plant part(s) affected: For the listed soft scales, the plant parts affected include leaves and fruit (Smith *et al.*, 1997; Peña and Mohyuddin, 1997; USDA, 2001).

Distribution:

Protopulvinaria pyriformis: Argentina, Azores, Bermuda, Canary Islands, Chile, Colombia, Comoros, Costa Rica, Cuba, Dominican Republic, France, Greece, Grenada, Guyana, Israel, Italy, Jamaica, Japan, Madeira Islands, Mauritius, Mexico, Peru, Portugal, Puerto Rico and Vieques Island, Saint Lucia, South Africa, Spain, Taiwan, Trinidad and Tobago, U.S. Virgin Islands, United States of America, Vietnam, Zimbabwe (Ben-Dov *et al.*, 2005).

Milviscutulus mangiferae: Antigua and Barbuda, Bangladesh, Brazil, Colombia, Comoros, Costa Rica, Côte d'Ivoire, Cuba, Dominican Republic, Ecuador, El Salvador, Fiji, Ghana, Guyana, Honduras, Hong Kong, India, Indonesia, Israel, Jamaica, Japan, Kenya, Madagascar, Malaysia, Martinique, Mauritius, Mexico, Nicaragua, Pakistan, Palau, Panama, Papua New Guinea, Philippines, Puerto Rico, Réunion, Seychelles, Singapore, Solomon Islands, South Africa, Sri Lanka, Taiwan, Tanzania, Thailand, Tonga, United States of America, U. S. Virgin Islands, Venezuela, Viet Nam, Western Samoa (Ben-Dov *et al.*, 2005).

Biology:

Protopulvinaria pyriformis: Adult females of *P. pyriformis* are 2–4 mm long, very flat and heart-shaped. Nymphs and young adults are transparent yellowish, and older females are yellowish-brown, with broad reddish, mottled marginal bands. Very old adults are uniformly brown. During egg laying, a short white ovisac is produced along the posterior margin, which

lifts the abdomen of the adult about 2 mm off the surface of the leaf (Diaz *et al.*, 2005; Gill, 1988).

Protopulvinaria pyriformis reproduces parthenogenetically and males are very rare (Ben-Dov and Hodgson, 1997). In Israel, two generation of the scale are established on avocado, oviposition taking place in March, August and October. (Ben-Dov and Hodgson, 1997). In avocado orchards in South Africa, *P. pyriformis* also has 2 generations per year, with peaks in the population of 1st instar larvae in November and March and of 2nd instar larvae in December and June. It is suggested that the periods November-December and April would be the best times to apply insecticides to control the pest (de Villiers, 1989). In Florida, there are several overlapping generations per year. The scale overwinters as nymphs, and adults produce several hundred eggs in spring. The entire life cycle is spent on the lower leaf surfaces (Gill, 1988).

Protopulvinaria pyriformis is occasionally a serious pest of avocados and certain ornamental plants in Florida. The scale produces abundant honeydew, and sooty mould is subsequently found on all parts of the host plant. Affected leaves dry out and fall, reducing the growth of the plant. Sap removal, host debilitation, honeydew production and sooty mould can be major economic effects (Gill, 1988; Diaz *et al.*, 2005). *Protopulvinaria pyriformis* is considered to be a pest of mango in Florida, where oil, malathion or parathion are recommended for its control. In the Canary Islands, mild and infrequent attacks of the coccid on mango have been recorded, while in Israel the slight infestations appear to cause no damage (Ben-Dov and Hodgson, 1997).

Various natural enemies have been recorded for *P. pyriformis*. In Spain, *Microterys flavus* was able to control up to 90% of the scale infestation during the summer (Diaz *et al.*, 2005). In Israel, various natural enemies attack *P. pyriformis*, but they are unable to curb heavy infestations. Hyperparasitoids such as *Marietta javensis* and *Pachyneuron concolor* sometimes cause considerable reductions in the populations of the primary parasitoids. Additionally, encapsulation of the parasitoid eggs prevents their successful development and may interfere with efficient biocontrol of the pest. For good overview of natural enemies see Ben-Dov and Hodgson (1997).

Sporadic outbreaks of *P. pyriformis* in avocado orchards in Florida have been controlled by organophosphorus insecticides. Recently in South Africa, insect growth regulators and organophosphorus scalicides were recommended against the pest. In Israel, mineral oils are used to control the pest in its younger stages (Ben-Dov and Hodgson, 1997).

Milviscutulus mangiferae: *Milviscutulus mangiferae* adults are elongate (2.5–4.0 mm long), irregularly pyriform, thin and flat, in shape, with triangular anal plates and mid and hind legs. Adults are yellowish green to brown in colour; larvae are translucent green. This species is reported to predominantly reproduce parthenogenetically. There is a low occurrence of males; not greater than 1 percent of the population (Otanés, 1936; Avidov and Zaitzov, 1960). Under

optimum conditions, the species is reported to be capable of producing three generations a year with development from hatching to maturity lasting 40–80 days; the pre-hatching period fluctuates between 30 and 113 days. Hence, development of a complete generation lasts 2.5–6.5 months. Female life span is reported to average 2–3.5 months. Progeny per female reportedly increased in summer averaging 65 in spring and winter, and 100 in summer. Conversely, natural mortality of nymphs and young was 86 percent during winter and spring and 49 percent in summer (Avidov and Zaitzov, 1960).

Milviscutulus mangiferae is considered polyphagous with ornamental plants and other species of economic importance as hosts (Kosztarab, 1997; Ben-Dov *et al*, 1997). The species is reported as a pest of economic significance on mango in Israel (Wysoki, 1997) and South Africa (Kamburov, 1987). It has been reported as being detrimental to young vegetative growth, flower and fruit production of mango in the Philippines (Otanés, 1936); to lemon trees in Taiwan (Takahashi, 1939); and to palms in the Seychelles where it caused pre-mature leaf-fall, branch dieback and even tree death (Vesey-Fitzgerald, 1953).

Sooty mould is reported to develop on honeydew excreted by *M. mangiferae*. In Israel, this is reported most often in summer, as the scale population peaks in October, when trees may be completely blackened. Scale populations of 600 per leaf have been recorded. Sooty mould interferes with plant respiration and photosynthesis, resulting in premature leaf-fall, poor flowering/fruiting and decline in vigour of the host. A significant economic impact results from the reduced quality of fruit covered with sooty moulds (Avidov and Zaitzov, 1960).

Soft scales are parasitised by species of the chalcidoid families Encyrtidae and Aphelinidae, and a few species belonging to other families (Hayat, 1997). For example, in the 1930s a severe infestation of *M. mangiferae* on mango, in Florida, was reported to be moderated by *Cephalosporium lecanii*, but a spray of oil emulsion/soap solution applied to both surfaces of the leaves was recommended to completely kill the scales and loosen mould (Berger, 1938). Infestation by *M. mangiferae* on coconut palms in the Seychelles, during the 1940s was reportedly brought under control by *Chilocorus nigritus* (Vesey-Fitzgerald, 1953). In Israel, *M. mangiferae* was parasitized by *Microterys frontatus* (Merc.) and *Coccophagus eritreaensis* Comp. However, parasitism was usually low, reaching about 20 percent during spring (Avidov & Zaitzov, 1960). The encapsulation response to parasitoids was studied by Blumberg and Swirski (1984). Attendance of the aggressive ant, *Oecophylla smaragdina* (Fabricius), is reported to reduce the rate of parasitization on *M. mangiferae* in Papua New Guinea (Buckley and Gullan, 1991).

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Mealybugs

Planococcus lilacinus (Cockerell) [Hemiptera: Pseudococcidae] – Coffee mealybug

Pseudococcus cryptus Hempel [Hemiptera: Pseudococcidae] – Citriculus mealybug

Pseudococcus jackbeardsleyi Gimpel & Miller [Hemiptera: Pseudococcidae] – Jack Beardsley mealybug

Rastrococcus spinosus (Robinson) [Hemiptera: Pseudococcidae] – Philippine mango mealybug.

Synonyms and changes in combination:

Planococcus lilacinus: *Pseudococcus tayabanus* Cockerell, 1905; *Dactylopius crotonis* Green, 1906 (nomen nudum); *Dactylopius coffeae* Newstead, 1908; *Pseudococcus coffeae* (Newstead); *Dactylopius crotonis* Green, 1911; *Pseudococcus crotonis* (Green); *Pseudococcus deceptor* Betrem, 1937; *Tylococcus mauritiensis* Mamet, 1939; *Planococcus crotonis* (Green); *Planococcus tayabanus* (Cockerell).

Pseudococcus cryptus: *Pseudococcus citriculus* Green 1922; *Planococcus cryptus* Silva *et al.*, 1968; *Pseudococcus spathoglottidis* Lit 1992; *Pseudococcus mandarinus* Das & Ghose 1996.

Pseudococcus jackbeardsleyi: previously known in the Philippines as *P. elisae* (e.g. in Lit and Calilung, 1994). However, Gimpel and Miller (1996) discovered that the species previously identified as *P. elisae* actually included two cryptic species, and described *P. jackbeardsleyi*.

Rastrococcus spinosus: *Phenacoccus spinosus* Robinson, 1918; *Puto spinosus* (Robinson); *Ceroputo spinosus* (Robinson).

Hosts:

Planococcus lilacinus: The host range of *P. lilacinus* is extremely wide. It attacks over 65 genera of plants in 35 families, including Anacardiaceae, Asteraceae, Euphorbiaceae, Fabaceae, Leguminosae and Rutaceae (Ben-Dov *et al.*, 2005). *Planococcus lilacinus* attacks *Theobroma cacao* (cocoa), *Psidium guajava* (guava), *Coffea* spp. (coffee), *Mangifera indica* (mango) (Ben-Dov *et al.*, 2005), and other tropical and sub-tropical fruits and shade trees (IIE, 1995).

Pseudococcus cryptus: *Ananas sativa*, *Annona muricata*, *Areca catechu*, *Artocarpus altilis*, *Artocarpus incisa* (breadfruit), *Artocarpus odoratissimus*, *Avicennia officinalis*, *Bauhinia purpurea*, *Calophyllum inophyllum*, *Citrus aurantifolia* (lime), *C. aurantium*, *C. grandis*, *C. limon* (lemon), *C. paradisi* (grapefruit), *C. reticulata* (mandarin), *C. sinensis* (orange), *Cocos nucifera* (coconut), *Coelogyne dayana*, *Coffea arabica* (Arabian coffee),

Coffea liberica, *Crinum asiaticum*, *Cyrtostachys renda*, *Dillenia indica*, *Elaeis guineensis*, *Eugenia malaccensis*, *Garcinia kydia*, *Garcinia mangostana* (mangosteen), *Glycine max*, *Hevea brasiliensis* (rubbertree), *Hibiscus tiliaceus*, *Lansium domesticum*, *Litchi chinensis* (lychee), *Mangifera indica* (mango), *Melastoma melobothricum*, *Melastoma normale*, *Millettia niuwenhuisii*, *Moringa oleifera*, *Musa sapientum*, *Myristica fragrans*, *Nephelium lappaceum*, *Ocotea pedalifolia*, *Osbornia ocdonta*, *Pandanus upoluensis*, *Passiflora foetida*, *Persea americana* (avocado), *Phalaenopsis amatilis*, *Phoenix dactylifera*, *Piper methysticum*, *Psidium guajava* (guava), *Punica granatum*, *Raphioperdalum bellatulum*, *Rhizophora apiculata*, *Ryparosa fasciculata*, *Spathoglottis plicata*, *Strychnos vanpurkii*, *Tamarindus indica*, *Vanda teres*, *Vitis vinifera* (grapevine) (Ben-Dov *et al.*, 2005).

Pseudococcus jackbeardsleyi: *Acalypha wilkesiana*, *Aeschynomene americana* (forage legume), *Aglaonema commutatum*, *Aglaonema simplex*, *Alpinia purpurata* (red ginger), *Ananas comosus* (pineapple), *A. cherimola* (custard apple), *A. muricata* (sour sop), *A. squamosa* (sweet sop), *Apium graveolens* (celery), *Bidens bipinnate*, *Blighia sapida* (akee apple), *Cajanus cajan* (pigeon pea), *Cajanus indicus* (pigeon pea), *Capsicum frutescens* (sweet pepper), *Carica papaya* (paw paw), *Cereus peruvianus* (cactus), *Chrysophyllum cainito*, *Citrus aurantiifolia* (Mexican lime), *Citrus paradisi* (grape fruit), *Coccinia grandis* (scarlet gourd), *Coffea arabica* (coffee), *Cordia curassavica*, *Coryphanta cubensis*, *Cucumis melon* (oriental melon), *Cucurbita pepo* (zucchini), *Cymbopogon citratus* (lemon grass), *Dendrobium tortile* (orchid), *Ficus decora* (rubber plant), *Ficus tricolour*, *Gardenia jasminoides* (cape jasmine), *Gossypium barbadense* (cotton), *Haematoxylum campechianum*, *Hibiscus cannabinus* (kenaf), *Hibiscus esculentus* (okra), *Hoya carnosa* (ornamental flower plant), *Hura crepitans* (sandbox tree), *Ipomoea batatas* (sweet potato), *Jatropha curca*, *Lantana camara* (lantana), *Litchi chinensis* (litchi), *Lycopersicon esculentum* (tomato), *Mangifera indica* (mango), *Manihot esculenta* (manioc), *Melochia tomentosa*, *Moringa oleifera* (drumstick), *Mormolyca balsamina*, *Musa paradisiaca* (banana), *Musa sapientum* (banana), *Nephelium lappaceum* (rambutan), *Nerium oleander* (Mediterranean shrub), *Phaseolus limensis* (lima bean), *Physalis peruviana* (cape gooseberry), *Physalis pubescens* (ground cherry), *Piper nigrum* (pepper), *Psidium guava* (guava), *Pueraria javanica*, *Punica granatum* (pomegranate), *Rhipsalis mesembrianthemoides*, *Sechium edule* (chayote), *Solanum melongena* (eggplant), *Solanum tuberosum* (potato), *Tamarindus indica* (tamarind), *Theobroma cacao* (cocoa), *Vitis*, *Zea mays* (maize), *Zingiber* (ginger) (Ben-Dov *et al.*, 2005).

Rastrococcus spinosus: *Anacardium occidentale* (cashew), *Antidesma nitidum*, *Artocarpus altilis* (breadfruit), *Artocarpus heterophyllus* (jackfruit), *Calophyllum* sp., *Citrus* sp., *Cocos nucifera* (coconut), *Ficus ampelas*, *Garcinia mangostana* (mangosteen), *Hevea brasiliensis* (rubber tree), *Lansium domesticum* (langsats), *Mangifera indica* (mango), *Mangifera odorata* (kuwini), *Nypa fruticans* (mangrove palm), *Plumeria robusta*, *Psidium*

guajava (guava), *Syzygium aqueum* (water apple), *Tabernaemontana* sp. (Ben-Dov *et al.*, 2005).

Plant part(s) affected: The listed mealybug species may affect the whole mango tree, including the fruit (CAB International, 2005).

Distribution:

Planococcus lilacinus: *P. lilacinus* occurs mainly in the Palaearctic, Malaysian, Oriental, Australasian and Neotropical regions, and is the dominant cocoa mealybug in Sri Lanka and Java (Entwistle, 1972). Williams (1982) reported that the species was probably introduced into the South Pacific from Southern Asia. According to Le Pelley (1968), the species does not occur above 1000 m.

In Asia, *P. lilacinus* is recorded from Bangladesh, Brunei Darussalam, Cambodia, China, India, Indonesia, Japan, Laos, Malaysia, Maldives, Myanmar, Philippines, Sri Lanka, Taiwan, Thailand, Viet Nam and Yemen (CAB International, 2005). For a full distribution listing, refer to CAB International (2005).

Pseudococcus cryptus: *P. cryptus* is widely distributed in South East Asia, tropical Africa, mideastern Mediterranean and South America. However, it is particularly a pest of citrus in Israel, into which it was inadvertently introduced in 1937 (Blumberg *et al.*, 1999). Following importation of the encyrtid *Clausenia purpurea* Ishii, the pest was successfully controlled.

Afghanistan, American Samoa, Andaman Islands, Argentina, Bangladesh, Bhutan, Brazil, British Indian Ocean Territory, Brunei, Cambodia, China, Costa Rica, El Salvador, Federated States of Micronesia, Hawaiian Islands, India, Indonesia, Iran, Israel, Japan, Kenya, Laos, Malaysia, Maldives, Mauritius, Nepal, Palau, Paraguay, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, U.S. Virgin Islands, Viet Nam, Western Samoa, Zanzibar (Ben-Dov *et al.*, 2005).

Pseudococcus jackbeardsleyi: Aruba, Bahamas, Barbados, Belize, Brazil, Canada, Colombia, Costa Rica, Cuba, Dominican Republic, El Salvador, Federated States of Micronesia, Galapagos Islands, Guatemala, Haiti, Hawaiian Islands, Honduras, Jamaica, Martinique, Mexico, Panama, Philippines, Puerto Rico, Singapore, Taiwan, Thailand, Trinidad and Tobago, U.S. Virgin Islands, United States of America, Venezuela (Ben-Dov *et al.*, 2005).

Rastrococcus spinosus: Bangladesh, Brunei, India, Indonesia, Cambodia, Laos, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Viet Nam (Ben-Dov *et al.*, 2005).

Biology: Mealybugs injure the host plant by sucking sap through their tubular stylets, and excreting large amounts of sugary honeydew onto fruit and leaves. Heavy infestations may

damage plants directly. Sooty mould fungus growth on the honeydew can render the fruit unmarketable and reduce the photosynthetic efficiency of leaves and cause leaf drop. Many mealybug species pose particularly serious problems to agriculture when introduced into new areas of the world where their natural enemies are not present (CAB International, 2005).

Planococcus lilacinus: Adult female *P. lilacinus* are broadly oval to rotund, with a length of 1.2–3.1 mm and width of 0.7–3.0 mm. The body is yellowish and covered by a wax coating and the mid-dorsal line is wide but indistinct (CAB International, 2005).

Female *P. lilacinus* studied in India produced an average of 252 nymphs in their lifetime; under warm humid conditions the nymphs took an average of 47 days to develop (Mukhopadhyay and Ghose, 1999). On cauliflower in India, females lay up to 150 eggs, which hatch within 24 hours. The nymphal period lasts 20–25 days (Loganathan and Suresh, 2001).

Planococcus lilacinus causes severe damage to young trees by killing the tips of branches and roots of many economically important species (USDA, 2001). These crops include citrus, guava, coffee, custard apple and mango. Cocoa crops all over the Oriental region are also affected (Ben-Dov *et al.*, 2005). Dense colonies can form patches on fruit and the honeydew produced attracts ants and may result in the development of sooty mould (CAB International, 2005).

The climatic conditions in the tropical regions of Asia and eastern Africa where *P. lilacinus* is found (USDA, 2001) are similar to those in areas of Australia. Therefore this species may survive and establish in Australia, if it were introduced. The importance of this species in India has warranted its control using chemicals and biological control agents on several commodities (Krishnamoorthy and Mani, 1998; Mani and Krishnamoorthy, 2000; CAB International, 2005).

Pseudococcus cryptus: No specific details on the biology of *Pseudococcus cryptus* are available. However, life history of a similar species of mealybug, *Planococcus citri* (Risso), is outlined below.

Adult female mealybugs of *P. citri* are white, about 3 mm long, and covered with a white, fluffy wax. White wax filaments surround the body margin, with the last pair up to one quarter the length of the female body. Males are tiny, gnat-like insects with one pair of fragile wings and non-functional mouthparts. They are short-lived (Smith *et al.*, 1997).

Pale yellow eggs are laid in an elongated, loose, cottony egg sac extending beneath and behind the female; 300–600 eggs are laid over 1–2 weeks, and these eggs hatch in about a week (Smith *et al.*, 1997). Very young nymphs (crawlers) are flat, oval and yellow. They develop through several stages (instars) over several weeks before reaching sexual maturity. There are three moults for females and four for males. Winged males emerge

from a tiny fluffy cocoon and fly to the female mealybug to mate (Drees and Jackman, 1999). The complete life cycle takes about 6 weeks during the summer and there are 3–6 generations per year (Smith *et al.*, 1997).

During winter, citrus mealybugs shelter in cracks in the branches or trunk, or in leaf axils. Young mealybugs move onto citrus fruit in late spring and usually settle under the calyx or between touching fruit (Smith *et al.*, 1997). Mealybugs produce honeydew, resulting in heavy growths of sooty mould (Smith *et al.*, 1997).

Following the introduction of *P. cryptus* into Israel in 1937, it was biologically controlled with the encyrtid *Clausenia purpurea* Ishii, prior to its recurrence in newer varieties of citrus (Blumberg *et al.*, 1999). Other natural enemies which attack nymphs and adults include the following parasitoids: *Anagyrus pseudococci*; *Cryptanusia luzonica*; *Paraplatycerus citriculus* and *Promuscidea unfasciatiiventris*; and following predators: *Amblyseius swirskii*; *Brumoides suturalis*; *Chilocorus nigrita*; *Diadiplosis hirticornis*; and *Pseudoscymnus dwipakalpa* (CAB International, 2005).

Pseudococcus jackbeardsleyi: Nymphs of *P. jackbeardsleyi* are light-yellow with oval, flattened and smooth bodies. Once feeding has begun, the mealybugs secrete a white waxy material that covers the body. Both males and females have three larval stages. The females change little in appearance throughout their life-cycle, except to grow in size. Males go through a pupal phase, where they enclose themselves in a white case in which they develop into an adult male (Metcalf and Flint, 1962; Mau and Kessing, 1993). The adult female mealybug is pinkish in color, oval and about 2.8 mm in length. Females are wingless throughout their life. The adult male mealybug is a tiny, two-winged insect. Males do not feed and die soon after mating. Eggs are laid within a compact, cottony, waxy sac beneath the abdomen of the female, and are usually found at the base of stems and leaves (Metcalf and Flint, 1962; Mau and Kessing, 1993).

Egg production lasts for 1–2 weeks, and the female dies soon after. Short-tailed mealybugs such as *P. jackbeardsleyi* generally lay 300–600 eggs per female. The eggs usually hatch in about 10 days and the first instars escape from the ovisac and crawl on the host searching for a suitable feeding site. First-instar larvae are sometimes transported by wind (Mau and Kessing, 1993; CAB International, 2005). Adult males can often be seen in flight early in the morning or late in the day when winds are generally calm. Mealybugs generally have from one to nine generations a year, depending on the weather conditions and species. The completion on one generation usually takes about one month under glasshouse conditions (Mau and Kessing, 1993; CAB International, 2005).

Mealybugs usually occur in protected areas on the host plant, such as the undersides of leaves, the axils of leaves, or in crevices on the trunk. *Pseudococcus jackbeardsleyi* occurs on a wide variety of fruit, vegetable and ornamental hosts. Although it has never been reported as a serious pest, its wide range of economic hosts and its ability to expand the

geographical range make it an ideal candidate as a future pest (CAB International, 2005). This mealybug could be injurious to a host plant in the absence of suitable natural enemies (Williams and Watson, 1988). Although no natural enemies have been reported in the literature, it is likely that this species has several. Mealybugs are usually associated with Chalcidoidea parasites and Coccinellid predators. Other natural enemies may include fungi, lacewings, flies and mites (CAB International, 2005). There is no information on possible chemical control of this mealybug, but the application of soaps and detergents are sometimes effective against mealybug pests (Mau and Kessing, 1993).

Rastrococcus spinosus: Adult female *R. spinosus* have no wings and are covered with a thick layer of white wax. They measure about 3.9 mm long and 2.5 mm wide. The male is 1.6 mm long with a pair of wings. There are long filaments of wax on all sides of their bodies, with the longest being at their rear (MTFIS, 2004).

Females lay eggs in a white, waxy egg sac. After hatching, the first instar crawlers move away and eventually settle on suitable feeding sites. The crawlers are the main dispersal stage and may be carried by wind or on animals. The mealybug may also be carried over longer distances on infested planting material. Females moult three times and males four times before turning into adults (MTFIS, 2004). On mango, the total development time for females and males is 28–32 and 30–32 days respectively (Ullah *et al.*, 1992).

Infestations on mango usually begin on the underside of leaves on terminal shoots. The mealybugs spread to young shoots and flowers as their population increases. Heavily infested leaves turn yellow, dry up and eventually fall off. The mealybug produces large amounts of honeydew that attracts sooty mould, reducing photosynthesis. The honeydew and sooty mould may also make fruits unmarketable (MTFIS, 2004).

In Pakistan, *Rastrococcus spinosus* is considered as an important pest of mangoes, and has also been recorded on oleander, banana, guava, orange and other plants (Mahmood *et al.*, 1980). It is recorded to be harmful to the young growth, flowers and mango fruit in the Philippines (Otanés, 1936). *Rastrococcus spinosus* has been found in US ports-of-entry on *Lansium* and *Tabernaemontana* from the Philippines and Singapore (Miller *et al.*, 2005).

Control measures for *R. spinosus* on mango include spraying with soap and water, and the removal of ants which transport the mealybug from tree to tree (Otanés, 1936). Some insecticides are effective against this mealybug, including Salithion, fenitrothion, carbaryl, dimethoate, methyl-parathion and phosphamidon (Ausaf and Ahmed, 1973). The natural enemies of *R. spinosus* include the lacewing *Odontochrysa ramburi* and the lepidopteran *Spalgis epeus* (CAB International, 2005).

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Mango aphid

Toxoptera odinae (van der Goot, 1917) [Hemiptera: Aphididae] – Mango aphid

Synonyms and changes in combination: *Toxoptera adivae* Shiraki, 1952; *Toxoptera araliae* Matsumura, 1917; *Toxoptera ficicola* Takahashi, 1921; *Toxoptera hameliae*, Theobald, 1929; *Toxoptera mokulen*, Shinji, 1922; *Toxoptera rutae*, Shinji, 1922; *Toxoptera sansho*, Shinji, 1922; *Toxoptera schlingeri*, Tao, 1961; *Toxoptera setariae*, Rusanova, 1942; *Toxoptera somei*, Essig & Kuwana, 1918; *Toxoptera spathodeae*, van der Goot, 1918; *Toxoptera taranbonis*, Matsumura, 1917 (Remaudière and Remaudière, 1997).

Hosts: *Anacardium occidentale* (cashew nut), *Anacardium* sp., *Aralia* sp., *Berberis* sp. (barberry), *Bidens* sp. (burmarigold), *Cassia fistula* (golden shower), *Cassia* sp. (senna), *Cinchona* sp., *Citrus aurantium* (sour orange), *Citrus* sp., *Coffea* sp. (coffee), *Croton* sp., *Datura fastuosa*, *Dioscorea* sp. (yam), *Duranta repens* (pigeonberry), *Erythrina indica* (Indian coral tree), *Fagopyrum* sp., *Gardenia florida* (cape jasmine), *Hamiltonia suaveolens*, *Heinsia* sp., *Hibiscus esculantus*, *Hibiscus rosa-sinensis* (China rose), *Jasminum* sp. (jasmine), *Kalopanax* sp., *Lannea* sp., *Leea* sp., *Maesa chisea*, *Maesa* sp., *Magnolia* sp. (magnolia), *Mangifera indica* (mango), *Momordica charantia* (bitter gourd), *Musa* sp. (banana), *Mussaenda* sp., *Pittosporum* sp., *Polyscias* sp., *Pyrus communis* (European pear), *Rhododendron* sp. (rhododendron), *Rhus semialata*, *Rhus* sp., *Senecio* sp. (groundsel), *Stephania* sp., *Stercula* sp., *Symplocos spicata*, *Tagetes patula* (French marigold), *Tetrapanax* sp., *Thea sinensis* (tea), *Todelia aculeata*, *Viburnum foetidum*, *Zanthoxylum ornatum*, *Ziziphus* sp. (Mondal *et al.*, 1976; Blackman and Eastop, 1984; Martin, 1989).

Plant part(s) affected: Leaves, flowers, fruit and young shoots (Mondal *et al.*, 1976; Shukla and Prasad, 1983; BAPHIQ, 2004).

Distribution: Burundi, China, India, Indonesia, Japan, Kenya, Korea (Republic), Laos, Malaysia, Nepal, the Philippines, South Africa, Sri Lanka, Taiwan, Thailand (Mondal *et al.*, 1976; Blackman and Eastop, 1984; Martin, 1989).

Biology: The wingless stage is small to medium-sized, pale, grey-brown to reddish brown (Mondal *et al.*, 1976; Blackman and Eastop, 1984). The head is brown, and antennae have six segments (Mondal *et al.*, 1976). The winged stage has a reddish-brown to dark brown abdomen (Blackman and Eastop, 1984). Both winged and wingless stages are approximately 1.3-2.4 mm in length (Mondal *et al.*, 1976; Blackman and Eastop, 1984). *Toxoptera odinae* reproduces asexually (Blackman and Eastop, 1984).

Aphids generally feed on phloem from plant stems and leaf veins (Carver *et al.*, 1991). Many tropical woody shrub species are hosts for this aphid species, and winged adults are

gregarious, aggregating on undersides of leaves of host plants along the main veins, or occurring as dense colonies on young shoots, especially along the mid ribs and stout veins (Mondal *et al.*, 1976; Blackman and Eastop, 1984). *Toxoptera odinae* usually attacks young leaves, although moderately old leaves can also be attacked (Mondal *et al.*, 1976). Individuals are often tended by ants (Mondal *et al.*, 1976; Blackman and Eastop, 1984). Heavy infestations occasionally cause curling of young leaves (Mondal *et al.*, 1976). Mango aphids excrete honeydew, causing the growth of sooty mould which can hinder photosynthesis (Shukla and Prasad, 1983).

Chemical control of mango aphid using methyl demeton, dimethoate and monocrotophos has been effective (Shukla and Prasad, 1983). *Toxoptera odinae* has not been implicated in the transmission of any plant viruses (Blackman and Eastop, 1984).

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Cocoa tussock moth

Orgyia australis postica (Walker, 1855) [Lepidoptera: Lymantriidae] – Cocoa tussock moth.

Synonyms and changes in combination: *Lacida postica* (Walker); *Notolophus australis posticus* (Walker); *Notolophus postica* (Walker); *Notolophus posticus* (Walker); *Orgyia postica* (Walker); *Orgyia ceylanica* Nietner, 1862; *Orgyia ocularis* Moore; *Orgyia posticus* (Walker) (CAB International, 2005).

Hosts: *Amherstia nobilis*, *Camellia sinensis* (tea), *Cinchona*, *Cinnamomum*, *Coffea* (coffee), *Durio zibethinus* (durian), *Erythrina spp.*, *Euphorbia longana* (longan), *Garcinia mangostana* (mangosteen), *Glycine max* (soyabean), *Hevea brasiliensis* (rubber), *Lablab purpureus* (hyacinth bean), *Leucaena leucocephala* (leucaena), *Litchi chinensis* (lichi), *Malpighia glabra* (acerola), *Mangifera indica* (mango), *Nephelium lappaceum* (rambutan), *Orchidaceae* (orchids), *Populus deltoides* (poplar), *Pyrus communis* (European pear), *Ricinus communis* (castor bean), *Rosa* (roses), *Syzygium cumini* (black plum), *Theobroma cacao* (cocoa), *Vigna radiata* (mung bean), *Vitis vinifera* (grapevine), *Ziziphus jujuba* (common jujube) (CAB International, 2005).

Plant part(s) affected: Fruit, leaf, stalk (CAB International, 2005).

Distribution: Bangladesh, Brunei Darussalam, China, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Papua New Guinea, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam (CAB International, 2005).

Biology: The eggs of *O. australis postica* are pillbox-shaped, pale whitish-brown, with a darker ring encircling a depressed top (CAB International, 2005). The larva is yellowish, with sparse brown hairs, and with one dorsal and two lateral brown bands. The head is red. The pupa is stout, glossy black with numerous small tufts of short hairs (CAB International, 2005).

The adult male has a wingspan of 21–30 mm. The head, thorax, abdomen and forewings are brown. The wing apex is slightly tinged with grey and the hind wings dark brown. The flightless female is brownish grey, thickly haired, with rudimentary wings (CAB International, 2005).

Males are in flight from January to July in Sumatra and in April and May in Taiwan (CAB International, 2005). The flightless females cling to the exterior of their cocoons and call males to them. Oviposition is generally on the cocoon, with up to 60% of eggs producing larvae (Sanchez and Laigo, 1968). Adults of *O. australis postica* live for about 5 days (Su, 1985; Cheng *et al.*, 2001).

The eggs hatch after 5–7 days at the optimal temperature of 25°C (Su, 1985; Cheng *et al.*, 2001). At this temperature, females laid an average of 152 eggs each on soybean leaves in the laboratory (Su, 1985). However, on cocoa leaves in the field, females have been observed to lay an average of 230 eggs each (Sanchez and Laigo, 1968).

Depending on temperature, the larvae take 16–64 days to develop; the fastest development occurring at 25–30°C (Cheng *et al.*, 2001). The number of larval instars may vary depending on the host plant (Su, 1987). Female larvae generally have four instars, and the male larvae three instars. As such, female larval development usually takes longer than male development. However, female pupal development is accelerated when compared to males, so the adults appear together (Gu *et al.*, 1992). Pupation takes place in a flimsy cocoon on either leaves or stems. The female and male pupal stages last 4–5 and 6–7 days, respectively (Sanchez and Laigo, 1968).

In Uttar Pradesh, India, widespread defoliation of mango has been reported, as well as fruit damage that rendered the fruit unsuitable for sale. Outbreaks also occurred in Lucknow, India (Fasih *et al.*, 1989). *Orgyia australis postica* is a serious pest of cocoa, and can cause total defoliation, killing or stunting the tree (Sanchez and Laigo, 1968). In Taiwan it is a major pest of cultivated grapevines and roses (CAB International, 2005).

Nuclear polyhedrosis viruses cause considerable larval mortality in the Philippines (Sanchez and Laigo, 1968). The parasitoids *Exorista* sp. and *Brachymeria lasus* have been recorded from India (Fasih *et al.*, 1989), although *B. lasus* may be a hyperparasite. In Bangladesh, *Brachymeria jambolana* was found to be a hyperparasite or secondary parasite of a tachinid of the genus *Carcelia*, a primary parasite of *O. australis postica* (CAB International, 2005).

Insecticides are also available for the control of this pest. For example, when 2nd and 3rd instar larvae were treated with CME-134 [teflubenzuron], 96–100% mortality resulted. Mortalities for 4th-instar and 5th-instar larvae were 75.0% and 55.5% respectively (Su, 1985).

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Mango thrips

Rhipiphorothrips cruentatus Hood, 1919 [Thysanoptera: Thripidae] – Mango thrips; grapevine thrips

Synonyms and changes in combination: *Rhipiphorothrips karna* Ramakrishna 1928.

Hosts: *Anacardium occidentale* (cashew nut), *Annona squamosa* (sugarapple), *Mangifera indica* (mango), *Psidium guajava* (guava), *Punica granatum* (pomegranate), *Rosa rugosa* (Rugosa rose), *Syzygium cumini* (black plum), *Syzygium samarangense* (water apple), *Terminalia catappa* (Singapore almond), *Vitis vinifera* (grapevine) (CAB International, 2005); *Areca catechu* (arecanut) (More *et al.*, 2003); *Jatropha curcas* (Rani and Sridhar, 2002); *Eugenia malaccensis* (wax apple) (Wen, 1989).

Plant part(s) affected: The mango thrips affects fruit and leaves of mango trees (CAB International, 2005).

Distribution: Afghanistan, Bangladesh, China, India, Myanmar, Oman, Pakistan, Sri Lanka, Taiwan, Thailand (CAB International, 2005).

Biology: The female mango thrips is between 1.2 and 1.5 mm long, and blackish-brown in colour, with the legs and antennal segments yellow, and the forewings pale with yellowish veins. Male mango thrips are similar to females in structure but with pronotum and abdomen yellow. The nymphs are white when they hatch from the eggs, but they soon develop red markings similar to those of other Panchaetothripinae.

Sexual reproduction is normal in *R. cruentatus*, but parthenogenesis is said to be common in India. The life cycle is temperature-dependent, with more eggs being produced, and life cycle lengths reduced, at high temperatures. In India, adults emerge from hibernating pupae in March, whereas in southern Taiwan the species continues to breed throughout the year although at varying rates (CAB International, 2005).

On wax apple in Taiwan, females each laid about 13 eggs. The egg stage lasted 13.0 days, and the 4 nymphal instars 4.7, 4.5, 1.3 and 2.0 days respectively (Chiu, 1984). Mango thrips overwinter as pupae, either on the plant or in the soil. On grapevine in India, adults pair 2–10 days after emergence, the males and females dying up to 7 and 20 days later respectively. The pre-oviposition period varies from 6 to 14 days. The eggs are laid in slits on the lower surface of the vine leaves. There are 5–8 generations annually (Rahman and Bhardwaj, 1937).

Both sexes survived submersion in water for 90 minutes, but not for 150 minutes. They survived exposure to 4°C for 1 hour, but not for 5 hours. Males were less resistant to cold than females (Rahman and Bhardwaj, 1937).

Rhipiphorothrips cruentatus feeds by sucking the contents from individual plant cells. On mango in Taiwan, injury was caused by puncturing and sucking sap from the epidermis of leaves and fruits. Affected areas turned dark or developed scars; leaves became blackened on their growing points, curled and finally dropped. In extreme cases, there was almost complete defoliation. Feeding punctures served as sources of entry for fungal attack (Lee and Wen, 1982).

In India, *R. cruentatus* is one of the most important insect pests of grapevines. Attacked leaves turn brown and fall prematurely, and the grape berries develop a corky surface when attacked (Rahman and Bhardwaj, 1937). In Taiwan, wax apple (*Syzygium samarangense*) has been severely attacked (Chiu, 1984), although several other crops have also been damaged including mango and guava, leading to yield reductions and to loss of market value (Chang, 1995).

The natural enemies of *R. cruentatus* are known to be important in controlling populations (CAB International, 2005). In India, *Ceranisis maculatus* has been observed to be an important parasitoid of *R. cruentatus*, with an average of 159 parasitized pupae per grapevine leaf. *Rhipiphorothrips cruentatus* was also parasitized by the Eulophid, *Thripodenus maculatus* (Rahman and Bhardwaj, 1937). Similarly, 77% parasitism by a *Ceranisis* species has been noted in Taiwan (Chiu, 1984; Chang, 1995). Other insects attacking this thrips are the workers of *Polistes divaceus* on rose bushes in India, and the lygeid bug *Geocoris ochropterus* (CAB International, 2005).

In India, carbaryl has been applied for the control of *R. cruentatus* on grapevine (Batra *et al.*, 1986), and in Pakistan, dimethoate and deltamethrin were applied against this thrips on mangoes (Khuhro *et al.*, 1987). In Taiwan, spraying cyhalothrin, deltamethrin and carbosulfan was effective in checking the grapevine thrips on wax apple (Wen, 1989). A recent study on the efficacy of different insecticides on *R. cruentatus* infesting grapevine showed that several sprays were effective, including deltamethrin, fenvalerate, dimethoate, endosulfan and malathion (Lakra and Dahiya, 2000).

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Mango scab

Elsinoë mangiferae Bitanc. & Jenkins [Dothideales: Elsinoaceae] – Mango scab.

Synonyms and change in combination: *Sphaceloma mangiferae* [anamorph] Bitanc. & Jenkins

Hosts: *Mangifera indica* (mango) (CAB International, 2005).

Plant part(s) affected: Leaves, growing points, inflorescence, and fruits/pods (CAB International, 2005).

Distribution: Australia (Northern Territory, Queensland), Brazil, Canada, China, Cuba, Dominican Republic, Haiti, India, Jamaica, Kenya, Nepal, Panama, Philippines, Puerto Rico, Taiwan, United States of America (CAB International, 2005).

Biology: Members of the genus *Elsinoë* are biotrophs. There are no reports of *E. mangiferae* infecting plants other than mango. The fungus and the disease have been described in Bitancourt and Jenkins (1946).

There has been very little work carried out on mango scab since an initial study in Florida, USA (Ruehle and Ledin, 1955). To some extent extrapolation from work with other species of *Elsinoë* can be applied, but much of the information is based on observations in the rural area around Darwin, Australia. The conidia of *Elsinoë* can only infect young tissue of the leaves, stem, flower, fruit stalk and young fruit. Mango scab, in common with the anthracnose fungus, is spread by rain splash and periods of free water are needed to produce conidia and for the germination of these conidia to produce new infections. It is only during wet weather that the characteristic, pale-brown growth of the conidiophores and conidia on active lesions has been found. Under extremely wet and gusty conditions, but in a sheltered situation, the disease was observed to spread 4.25 m. In unsheltered situations, spread over longer distances would be expected. Mango scab is not seed transmitted (CAB International, 2005).

E. mangiferae produces two types of spores: ascospores (the sexual stage) and conidia (the asexual stage). The asexual stage is sometimes referred to by a different name: *Sphaceloma mangiferae*. In the original study of this fungus (Bitancourt and Jenkins, 1946) the ascospore state was only rarely found and it was concluded that the asexual conidia were responsible for the bulk of infections. Scientific identification of mango scab is best based on a combination of the symptoms with isolation of the fungus in culture (CAB International, 2005).

The symptoms of mango scab are extremely diverse depending on factors such as the plant part affected, cultivar, age of tissue at infection, inoculum potential, water and mineral nutrition (expressed as plant vigour and lushness) and possibly the amount and distribution

of free water. Only young tissue is susceptible to infection, for instance fruit is no longer susceptible after it reaches about half size. The occurrence of all symptoms is dependent on the availability of free water when the tissue is at the susceptible stage. Some of the symptoms can be confused with physical or insect injury or infection with other diseases (Condé *et al.*, 1997).

In Darwin, Australia, the most noticeable symptom is on the fruit (Condé *et al.* 1997). Initially small black lesions form on the newly set fruit. These lesions can be easily confused with the black lesions of anthracnose and heavily affected fruits fall off the tree. Lesions on the fruit of the cultivar Kensington Pride, which remain on the tree, develop into light-brown scabs or scar tissue, either as small scabs or as large, irregular scar tissue when the lesions coalesce. As scabs develop they consist of scar tissue with a central scab which can, in some cases, be lifted off. Anthracnose infection does not produce this type of scar tissue on the fruit. If there are only a few fruits affected the disease can be confused with abrasion injury. More diverse lesions occur on the cultivar Irwin, which is popular in Darwin, Australia. These lesions range from small black spots, which could be mistaken for spray injury, to small and large scarred areas, the large areas being accompanied with a depressed distortion of the fruit. The scarred areas in all cultivars could be mistaken for damage caused by insect injury. However, with mango scab, there is no indication of any chewing to the fruit and significant numbers of potentially damaging insects will not be found. Of the two cultivars investigated in some detail in the Darwin area, Irwin has been found to incur greater damage than Kensington Pride. Unlike anthracnose, mango scab lesions do not develop into a soft rot as the fruit matures.

The most common symptom on stem tissue is the occurrence of numerous slightly raised, grey, oval to elliptical lesions. If conditions are somewhat dry, the lesions will be smaller and black. Lesions on the inflorescence or frutescence may initially appear similar to those of anthracnose, however, on closer inspection or microscopic examination they are seen to be raised structures in contrast to the non-raised lesions of anthracnose. Another symptom consisting of large, light-tan, corky areas, resembling the scar tissue caused by insect injury, has been observed on stems. Diverse lesions occur on the cultivar Irwin, which is popular in Darwin, Australia. These lesions range from small black spots, which can be mistaken for spray injury, to small and large scarred areas, the large areas with a depression of the fruit. The scarred areas in all cultivars can be mistaken for damage caused by insect injury (CAB International, 2005).

A wide range of symptoms has been observed on the leaves although these symptoms are largely overshadowed by the more dramatic damage on the fruits. Common symptoms are: brown necrotic spots with halos; edge lesions associated with hydathodes; corky lesions on the lower leaf surfaces; or elongated, dark lesions along main veins under the leaf. Other symptoms on leaves are lesions with central scabs and numerous small lesions about 0.1 mm diameter along secondary veins. Leaves often appear distorted due to the effects of

marginal or edge lesions and other lesions on the growth and expansion of the leaf (CAB International, 2005).

In nurseries a similar range of symptoms (shot hole, numerous small necrotic lesions, distorted leaves) occurs on the leaves as occurs in orchards but these tend to be more prominent on the young growth. Defoliation is common in severe infections. Small, black or elongated, grey scab lesions are also found on young stem tissue (CAB International, 2005).

Various symptoms of mango scab can be confused with other conditions, for example anthracnose, *Amblypelta* damage to fruit and leaves, contact injury to fruit or leaves, algal infection and damage caused by *Monolepta* species to fruit. For this reason, one or a few scarred fruit, or a few mid-vein leaf lesions are not definitive of scab in the field. A larger number of scarred fruit is indicative of the disease. Microscopic examination is necessary to separate mango scab from other causes. In dry situations, leaf lesions tend to be fewer, smaller and black and could easily pass unnoticed (CAB International, 2005).

Scientific identification of mango scab is best based on a combination of the symptoms with isolation of the fungus in culture. *E. mangiferae* produces a characteristic, slow-growing, small, dense, dark, volcano-shaped colony in common with other species of *Elsinoë*. Conidia are useful to some extent but are not particularly distinctive in size and shape and may be similar to the conidia of the common saprobic species of *Cladosporium*, although these have a distinctive thickened scar. Furthermore, the conidia may be difficult to find, being produced only when the leaves are exposed to prolonged periods of wet weather (e.g. rain, heavy fogs) (CAB International, 2005).

Isolation of *E. mangiferae* in culture is best from young tissue. It is virtually impossible to obtain the fungus from older tissues due to the build-up of endophytes/saprobies as tissues mature (CAB International, 2005).

If controlled, mango scab should cause little economic damage. Without chemical control, losses as high as 90% have been observed in one orchard during an investigation in 1996 and 1997 in Darwin, Australia (BD Condé, NT Department of Primary Industry and Fisheries, Darwin, Australia, unpublished data) (CAB International, 2005).

In severe scab infections on trees or nursery stock, it may be beneficial to prune away old infected stems to reduce the levels of inoculum. Copper fungicides (oxychloride, hydroxide or oxide) need to be applied from at least flower bud emergence to flowering, and then after the fruit has set till the fruit are half-grown, in order to protect the fruit from infection. Copper fungicides mixed with certain other chemicals can cause phytotoxic burning symptoms on mango tissue (Condé *et al.*, 1997). Experiments in Darwin, Australia, indicate that the use of copper fungicides alone will not cause damage to flowering or fruit set. Where copper sprays are used against flowering anthracnose, mango scab may be undetectable (CAB International, 2005).

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