Australian Government

Biosecurity Australia

Final Report

Extension of Existing Policy for Sweet Oranges from Italy

July 2005

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Every effort has been made to ensure that the information provided in this document is true and accurate at the time of publication. A number of factors may affect the accuracy or completeness of this information. These factors include changes in pest and disease status, and scientific information.

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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
Biological control agent	a natural enemy, antagonist or competitor, or other self-replicating biotic entity, used for pest control
Biosecurity Australia	a prescribed Agency within the Australian Government Department of Agriculture, Fisheries and Forestry
Certificate	an official document, which attests to the phytosanitary status of any consignment affected by phytosanitary regulations
Competitor	an organism that competes with pests for essential elements (e.g. food, shelter) in the environment
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
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
Harmonisation	the establishment, recognition and application by different countries of phytosanitary measures based on common standards
Host range	species of plants capable, under natural conditions, of suiting a specific pest

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 as 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
MPAF	Ministero Della Politiche Agricole e Forestali (Italian Ministry of Agricultural and Forestry Policies)
National Plant Protection Organisation	official service established by a government to discharge the functions specified by the IPPC (DAFF is Australia's NPPO)
Official	established, authorised or performed by a National Plant Protection Organisation
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
PBPM	Plant Biosecurity Policy Memorandum
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 free place of production	place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period
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
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
WTO	World Trade Organization

EXECUTIVE SUMMARY

This extension of existing policy recommends that sweet oranges from Italy be allowed entry into Australia subject to phytosanitary measures for pink citrus rust mite, Mediterranean fruit fly, citrophilus mealybug, citrus pyralid, citrus flower moth, western flower thrips and predatory mites (phytoseiid mites and stigmaeid mites). These pests require the use of risk management measures in addition to Italy's standard commercial production practices, to reduce the risk to meet Australia's appropriate level of protection (ALOP).

A combination of risk management measures and operational systems will reduce the risk associated with the importation of sweet oranges from Italy to meet Australia's ALOP, specifically:

- cold disinfestation for Mediterranean fruit fly;
- inspection and remedial action for pink citrus rust mite, citrophilus mealybug, citrus pyralid, citrus flower moth, western flower thrips and predatory mites; and
- supporting operational systems to maintain and verify phytosanitary status.

Australia initiated an import risk analysis for the importation of citrus from Italy in November 1998, following a request for market access from the Italian Ministero Della Politiche Agricole e Forestali (Ministry of Agricultural and Forestry Policies) (MPAF) in March 1998. In September 2003, MPAF advised that Italy's market access request was specifically for blood oranges originating from the regions of Sicily and Calabria. Blood oranges are cultivars of sweet orange (*Citrus sinensis* (L.) Osbeck).

An assessment by Biosecurity Australia of the pests potentially associated with sweet oranges from Italy indicated that the pests do not pose significantly different quarantine risks, or require significantly different management measures, than those for which policy exists, namely for the pests associated with citrus from Egypt, Israel and Spain. In view of this, Biosecurity Australia determined that the market access request from Italy could be progressed as an extension of existing policy. Accordingly, Biosecurity Australia advised stakeholders on 5 March 2004 (Plant Biosecurity Policy Memorandum 2004/05) that the access request would be considered as an extension of existing policy.

Although the proposed policy extension was initially for blood oranges from Sicily and Calabria, the technical information supplied by MPAF was sufficiently comprehensive to enable import conditions to be developed for sweet oranges from the whole of Italy.

Biosecurity Australia circulated the draft extension of existing policy report for sweet oranges from Italy in March 2005. Stakeholder comments were considered and material matters raised have been incorporated into, or addressed in, this final extension of existing policy report.

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 was considered to be above Australia's ALOP, risk management measures were identified and selected.

Consultation with MPAF, and input from stakeholders on the draft import conditions, has resulted in a set of final risk management measures. Details of these measures, including their objectives, are provided within this final extension of existing policy report.

Biosecurity Australia has made a number of changes in the risk assessments following consideration of stakeholder comments on the draft extension of existing policy. These changes include:

- the removal of the mites *Brevipalpus cuneatus*, *Amblyseius largoensis* and *Amblyseius messor* from the pest list. These mites had been recorded on citrus in Italy but were not found in subsequent surveys;
- the addition of the fungus *Ascochyta hesperidearum* and the viroids citrus viroid III, citrus viroid IV and citrus bent leaf viroid to the pest list;
- an increase in the probability of distribution and consequences of pink citrus rust mite (*Aculops pelekassi*) to low and moderate respectively following reconsideration of the wind dispersal capability of this mite and its resistance to dithiocarbamate insecticides;
- an increase in the probability of distribution of citrus red mite (*Panonychus citri*) to low following reconsideration of the ability of this mite to balloon on wind currents;
- the inclusion of a detailed risk assessment for western flower thrips (*Frankliniella occidentalis*) following confirmation that it is absent from the Northern Territory and under official control in Tasmania;
- the inclusion of detailed risk assessments for phytoseiid mites, yellow mite (*Lorryia formosa*) and stigmaeid mites following reconsideration of their potential for consequences; and
- the inclusion of detailed risk assessments for *Phytophthora palmivora*, *Phytophthora syringae*, *Nematospora coryli* and *Septoria citri* following reconsideration of their potential for consequences.

1 INTRODUCTION

Biosecurity Australia is a prescribed Agency within the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) 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 September 2003, the Italian Ministero Della Politiche Agricole e Forestali (Ministry of Agricultural and Forestry Policies) (MPAF) advised that Italy's market access request for citrus was limited to sweet oranges (*Citrus sinensis*).

Quarantine policy currently exists for the import of citrus into Australia from Egypt, Israel, New Zealand, Spain and the USA (Arizona, California, and Texas). An assessment by Biosecurity Australia of the pests potentially associated with sweet oranges from Italy indicated that the pests do not pose significantly different quarantine risks, or require significantly different management measures, than those for which policy exists, namely the pests associated with citrus from Egypt, Israel and Spain.

In view of the similarity in climatic conditions and the quarantine risk associated with citrus in the Mediterranean region (Table 1), Biosecurity Australia determined that the market access request for sweet oranges from Italy could be progressed as an extension of existing policy. Accordingly, Biosecurity Australia advised stakeholders that the access request would be considered as an extension of existing policy in Plant Biosecurity Policy Memorandum 2004/05 on 5 March 2004.

In the pest risk analysis (PRA) process for sweet oranges from Italy into Australia, Biosecurity Australia first categorised the pests associated with sweet oranges from Italy to identify the quarantine pests for Australia. The likelihood of entry, establishment or spread and associated potential consequences were then assessed to arrive at an unrestricted risk estimate for each quarantine pest.

Risk management measures, in addition to the standard commercial practices, were then identified for each quarantine pest that was above the appropriate level of protection (ALOP) for Australia and used to develop recommended import conditions.

This report contains the following:

- the background to this extension of existing policy and Australia's current quarantine policy for imports of fresh citrus fruit;
- the methodology and results of pest categorisation and risk assessment;
- risk management measures;
- final import conditions; and
- a table of stakeholders who commented on the draft extension of existing policy and a summary of issues raised by these stakeholders.

2 PROPOSAL TO IMPORT SWEET ORANGES FROM ITALY

2.1 Background

A market access request for citrus (sweet orange, lemon, mandarin and clementine) from Italy to Australia was received in March 1998. Background information on citrus production and a pest list for *Citrus* species for Italy was provided by MPAF.

Stakeholders were advised in November 1998 that an IRA was to commence for citrus fruit from Italy. Stakeholders were advised in May 1999 that the routine IRA process would be used.

In a letter dated 2 September 2003, MPAF advised that Italy's market access request was specifically for blood oranges originating from the regions of Sicily and Calabria. Blood oranges are cultivars of sweet orange (*Citrus sinensis* (L.) Osbeck).

A comparison of the pests potentially associated with the importation of sweet oranges from Italy indicated that there was a substantial commonality between these pests and the pests already assessed in the development of import policy for citrus fruit from Egypt, Israel and Spain. The pests for which policy existed included citrus red mite, Mediterranean fruit fly, whiteflies (woolly & bayberry), scales (palm, Glover's, chaff & black parlatoria), Citrophilus mealybug, citrus pyralid, citrus flower moth, western flower thrips and mal secco. Details for these pests for Italy and Egypt, Israel and Spain are given in Table 1.

Table 1: Comparison of the occurrence of quarantine pests of citrus for Mediterranean Countries (Egypt, Israel and Spain) with pests in Italy

Pest Type	Common name	Countries			
		Italy	Israel	Egypt	Spain
ARTHROPODS					
Acari (mites)					
Panonychus citri McGregor [Acari: Tetranychidae]	Citrus red mite*	✓	✓		✓
Diptera (flies)					
Ceratitis capitata (Wiedemann) [Diptera: Tephritidae]	Mediterranean fruit fly; Medfly	✓	✓	✓	✓
Hemiptera (aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whiteflies)					
Aleurothrixus floccosus (Maskell) [Hemiptera: Aleyrodidae]	Woolly whitefly	✓	✓	✓	✓
Chrysomphalus dictyospermi (Morgan) [Hemiptera: Diaspididae]	Palm scale*	✓	✓	✓	✓
Lepidosaphes gloverii (Packard) [Hemiptera: Diaspididae]	Glover's scale*	✓	✓	✓	✓
Parabemisia myricae (Kuwana) [Hemiptera: Aleyrodidae]	Bayberry whitefly	✓	✓	✓	✓
Parlatoria pergandii Comstock [Hemiptera: Diaspididae]	Chaff scale*	✓	✓	✓	✓
Parlatoria ziziphi (Lucas) [Hemiptera: Diaspididae]	Black parlatoria scale	✓	✓	✓	✓

Pest Type	Common name	Countries			
		Italy	Israel	Egypt	Spain
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug*	✓			✓
Lepidoptera (moths, butterflies)					
Cryptoblabes gnidiella (Millière) [Lepidoptera: Pyralidae]	Citrus pyralid	✓	✓	✓	✓
Prays citri Millière [Lepidoptera: Yponomeutidae]	Citrus flower moth	✓	✓	✓	✓
Thysanoptera (thrips)					
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips	✓	✓		✓
PATHOGENS					
Fungi					
Phoma tracheiphila (Petri) Cif	Mal secco	✓	✓		

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

Existing policy for mal secco for Israel was based on production area freedom. Mal secco occurs throughout Italy and production area freedom could not be used as the mitigation measure for this disease for Italy. By Italy limiting its market access request to *Citrus sinensis*, the natural host resistance of this species to mal secco could be assessed in the risk assessment for mal secco.

PBPM 2004/05 advised stakeholders on 5 March 2004 that the Italian Citrus IRA would cease and Italy's market access request would be progressed as an extension of existing policy based on current citrus quarantine policy for Egypt, Israel and Spain.

On the basis of the information provided by MPAF, the PRA was only conducted for sweet oranges from Italy.

The draft extension of existing policy report for sweet oranges from Italy was released in March 2005 and stakeholders were requested to provide comments within 30 days of release. Biosecurity Australia received comments from six stakeholders. Stakeholder comments were considered and material matters raised were incorporated into, or addressed in, this final report.

2.2 Administration

2.2.1 Scope

Biosecurity Australia has considered the quarantine risks associated with the importation of fresh sweet orange fruit from Italy in the PRA section of this extension of existing policy.

The PRA forms the basis for development of import policy with respect to the entry of sweet orange fruit into Australia from Italy that has been cultivated, harvested, packed and transported to Australia under commercial conditions.

The policy developed in this PRA for sweet orange is applicable to any cultivar of sweet orange from Italy.

2.2.2 Predatory mites

A range of predatory mites has been reported on citrus in Italy. Some of these predatory mites form part of integrated pest management programs and are available commercially to control target pests. The species not present in Australia are potentially beneficial to various production systems in Australia but they could also pose a risk to the environment. In addition, sweet orange imports represent a possible pathway for entry of predatory mites. Biosecurity Australia has included assessments of predatory mites associated with sweet orange in Italy in this extension of existing policy.

2.2.3 Contaminating pests

In addition to the pests of sweet orange in Italy, there are other arthropods that may be carried by the fruit (present on the import pathway). Biosecurity Australia considers these arthropods as contaminating pests, which can pose quarantine risks. These risks are addressed for most contaminating pests by AQIS's standard inspection procedures.

2.3 Australia's Current Quarantine Policy for Fresh Citrus Fruit

The Commonwealth Government is responsible for regulating the movement of plants and plant products into and out of Australia. However, the 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.

2.3.1 International policy

Fresh citrus fruit may be imported into Australia from Egypt, Israel, New Zealand, Spain and the USA (Arizona, California, and Texas). General import requirements for all fruits and vegetables and specific import conditions for citrus from these countries can be found in the AQIS Import Condition (ICON) database at http://www.aqis.gov.au/icon.

This extension of existing policy for sweet oranges from Italy is based on current citrus quarantine policy for Egypt, Israel and Spain. Current policy for the import of citrus fruit from these countries requires:

- operational systems for the maintenance and verification of the phytosanitary status of imported citrus fruit;
- cold treatment for Medfly (pre-shipment or in-transit);
- phytosanitary inspection and certification by the National Plant Protection Organisation;
- on-arrival phytosanitary inspection by AQIS and remedial action for live quarantine pests and regulated articles; and
- production area freedom for mal secco.

The import conditions for citrus fruit from Egypt, Israel and Spain are summarised below.

2.3.1.1 Egypt

Australia has an agreement with the Central Administration for Plant Quarantine (CAPQ) that sets out the plant quarantine conditions governing the import of commercial fresh citrus fruit into Australia.

Citrus of the following types can be imported from Egypt: lime (*Citrus aurantifolia*), sweet orange (*Citrus sinensis*) and Tahitian lime (*Citrus latifolia*).

The following ICON conditions apply:

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

Condition C9488 – Fresh citrus from Egypt.

Condition C9502 – Fresh fruit species.

Condition C9514 – Verification of in-transit cold treatment of citrus from Egypt.

The general requirements (Condition C6000) include an AQIS import permit, a quarantine entry, a phytosanitary certificate, freedom from regulated articles and on-arrival inspection and remedial action by AQIS.

All *Citrus* spp. imported from Egypt must undergo a cold disinfestation treatment for Mediterranean fruit fly (*Ceratitis capitata*). The cold treatment is permitted to be undertaken pre-shipment or in-transit. In the event of a treatment failure, completion of the treatment is permitted on arrival in Australia.

A Phytosanitary Certificate issued by CAPQ must accompany every consignment of fresh citrus fruit from Egypt and bear the following additional declaration:

> "The consignment was produced and inspected in accordance with the Agreement on plant quarantine between CAPQ and AQIS"

All citrus is required to undergo a post harvest wash to control *Alternaria alternata* (Alternaria brown spot).

2.3.1.2 Israel

Australia has an agreement with the Plant Protection and Inspection Service (PPIS) that sets out the plant quarantine conditions governing the import of commercial fresh citrus fruit into Australia.

Citrus of the following types can be imported from Israel: etrog (*Citrus medica*), grapefruit (*Citrus paradisi*), mandarin or tangerine (*Citrus reticulata*), pomelo (*Citrus grandis*), sweet orange (*Citrus sinensis*) and tangelo (*Citrus reticulata x C. paradise*).

The following ICON conditions apply:

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

Condition C6027 – Fresh citrus spp. from Israel.

The general requirements (Condition C6000) include an AQIS import permit, a quarantine entry, a phytosanitary certificate, freedom from regulated articles and on-arrival inspection and remedial action by AQIS.

All *Citrus* spp. imported from Israel must undergo a cold disinfestation treatment for Mediterranean fruit fly (*Ceratitis capitata*). The cold treatment is permitted to be undertaken pre-shipment or in-transit. In the event of a treatment failure, completion of the treatment is permitted on arrival in Australia.

Phytosanitary certificates must be endorsed with the following additional declaration:

"The area in which the fruit was grown was free of Mal secco"

2.3.1.4 Spain

Australia has a Specific Commodity Understanding (SCU) with the Ministerio de Agricultura, Pesca y Alimentación (MAPA) that sets out the plant quarantine conditions governing the import of commercial fresh citrus fruit into Australia.

Citrus of the following types can be imported from Spain: Calamondin (*Citrus mitis*), cumquat (*Fortunella spp.*), grapefruit (*Citrus paradisi*), kaffir lime (*Citrus hystrix*), lemon (*Citrus limon*), lime (*Citrus aurantifolia*), mandarin or tangerine (*Citrus reticulata*), sour orange (*Citrus aurantium*), sweet orange (*Citrus sinensis*), pomelo (*Citrus grandis*), Rangpur lime (*Citrus limonia*), Tahitian lime (*Citrus latifolia*), tangelo (*Citrus reticulata x C. paradisi*) and tangor (*Citrus reticulata x C. sinensis*).

The following ICON conditions apply:

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

Condition C6061 – Pre-shipment or in-transit cold treatment of Citrus for the disinfestation of Medfly.

The general requirements (Condition C6000) include an AQIS import permit, a quarantine entry, a phytosanitary certificate, freedom from regulated articles and on-arrival inspection and remedial action by AQIS.

All *Citrus* spp. imported from Spain must undergo a cold disinfestation treatment for Mediterranean fruit fly (*Ceratitis capitata*). The cold treatment is permitted to be undertaken pre-shipment or in-transit. In the event of a treatment failure, completion of the treatment is permitted on arrival in Australia.

Phytosanitary certificates are to be endorsed with the following three additional declarations:

"All fruit in the consignment is grown in mainland Spain"

"The consignment was produced and inspected in accordance with the MOU on plant quarantine between MAPA and AQIS"

"MAPA have supervised the calibration and the placement of fruit sensors into the fruits within the container/s in accordance with the requirements of the SCU and that cold disinfestation treatment has been initiated"

2.3.2 Domestic arrangements

The Interstate Certification Assurance (ICA) scheme facilitates interstate trade. It recognises pest free areas within Australia and ensures produce entering such areas is free of specific pests of quarantine concern. The scheme is accepted by all Australian States and the Northern Territory and is based on documented operational procedures developed by the Queensland Department of Primary Industries (QDPI) in conjunction with industry and interstate quarantine authorities. It provides a harmonised approach to the audit and accreditation of businesses throughout Australia and the mutual recognition of Plant Health Assurance Certificates accompanying consignments of produce moving within or between States and Territories. Interstate quarantine authorities maintain the right to inspect certified produce at any time and to refuse to accept a certificate where produce is found not to conform to specific requirements.

Several ICAs have specific conditions or restrictions on the interstate movement of fresh citrus fruit produced in Australia. The main pests of interstate quarantine concern are the Queensland fruit fly (*Bactrocera tryoni*) and Mediterranean fruit fly (*Ceratitis capitata*).

Interstate requirements are based on the following ICAs:

ICA-01: Post-harvest dipping with dimethoate or fenthion.

ICA-02: Post-harvest flood spraying with dimethoate or fenthion.

ICA-04: Post-harvest fumigation with methyl bromide.

ICA-07: Post-harvest cold treatment.

2.4 Citrus Production in Italy

Citrus production in Italy, although widely distributed geographically, is located primarily in the southern regions of Sicily and Calabria. Sicily produces 61% of national production, followed by Calabria with 28%. The remaining regions produce 11%. The orange is the most cultivated citrus fruit in Italy, with 108,000 hectares under production. Blood oranges make up about 60% of orange production. When blood oranges are grown in Mediterranean type climates with hot days and cool nights, the fruit develops a deep red flesh colour from the development of anthocyanins.

Italy is proposing to export the following blood orange cultivars to Australia:

Tarocco has round, medium to large, seedless fruit that have an ideal balance between sweetness and acidity, a distinctive aroma and mature from mid-December to April; and

Moro has round to oval, medium, seedless fruit with a characteristic blood orange flavour that mature from mid-December to January.

3 METHOD FOR PEST RISK ANALYSIS

An outline of the methodology used for pest risk analysis (PRA) is given to provide the context for the technical information that is provided later in this document. In accordance with the International Standards for Phytosanitary Measures Publication Number 11 *Pest Risk Analysis for Quarantine Pests including Analysis of Environmental Risks and Living Modified Organisms* (ISPM 11), 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 entry, establishment or 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 or 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 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.

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 2.

Table 2: 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 3.

Table 3: 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 4.

Table 4: The assessment of local, district, regional and national consequences

Impact score	*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

Level

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 appear 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 5. The cells of this matrix describe the product of likelihood of entry, establishment or spread and consequences of entry, establishment or spread.

Table 5: Risk estimation matrix

Likelihood of entry, establishment or spread						
High likelihood	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible likelihood	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk
	Negligible impact	*Very low*	*Low*	*Moderate*	*High*	*Extreme impact*

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 5 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 exceeds 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, 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 is above the ALOP as required and are presented in the Pest Risk Management section of this document. The pests that are above 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 document.

4 PEST RISK ANALYSIS

4.1 Stage 1: Initiation

Initiation of this PRA followed advice from MPAF in September 2003 that Italy's market access request was specifically for blood oranges from the regions of Sicily and Calabria.

A list of pests likely to be associated with sweet oranges from Italy (i.e. the biosecurity risk pathway) was generated from information supplied by MPAF and 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 Western Australia for the pests that occur in Australia but for which Western Australia has regional freedom. 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 sweet oranges from Italy. The pathway in this PRA is considered to be sweet oranges for human consumption from export orchards in Italy.

4.2 Stage 2: Pest Risk Assessment

4.2.1 Pest categorisation

The quarantine pests for sweet oranges from Italy have been determined through a comparison of the pests recorded on *Citrus* species in Italy and Australia (present or absent, or present but with a limited distribution and under official control [Appendix 1a], presence on the pathway under consideration [Appendix 1b], and potential for establishment or spread and associated consequences [Appendix 1c]). A number of pests are present in Australia but are absent from Western Australia (based on advice provided to Biosecurity Australia by the Department of Agriculture Western Australia). Pests that do not meet the definition of a quarantine pest are not considered further in the PRA.

Quarantine pests for sweet oranges from Italy, determined through this process of pest categorisation, are listed in Table 6. These pests require detailed risk assessment since they meet the IPPC criteria for a quarantine pest, specifically:

- the pest is known to be associated with sweet oranges in Italy;
- 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;
- the pest has the potential for establishment or spread in the PRA area; and
- the pest has the potential for consequences.

Table 6: Quarantine pests for sweet oranges from Italy

Pest Type	Common name
ARTHROPODS	
Acari (mites)	
Aculops pelekassi (Keifer) [Acari: Eriophyidae]	Pink citrus rust mite
Panonychus citri McGregor [Acari: Tetranychidae]	Citrus red mite*
Lorryia formosa Cooreman [Acari: Tydeidae]	Yellow mite
Diptera (flies)	
Ceratitis capitata (Wiedemann) [Diptera: Tephritidae]	Mediterranean fruit fly
Hemiptera (aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whiteflies)	
Aleurothrixus floccosus (Maskell) [Hemiptera: Aleyrodidae]	Woolly whitefly
Chrysomphalus dictyospermi (Morgan) [Hemiptera: Diaspididae]	Palm scale*
Lepidosaphes gloverii (Packard) [Hemiptera: Diaspididae]	Glover's scale*
Parabemisia myricae (Kuwana) [Hemiptera: Aleyrodidae]	Bayberry whitefly
Parlatoria pergandii Comstock [Hemiptera: Diaspididae]	Chaff scale*
Parlatoria ziziphi (Lucas) [Hemiptera: Diaspididae]	Black parlatoria scale
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug*
Unaspis yanonensis (Kuwana) [Hemiptera: Diaspididae]	Arrowhead scale
Lepidoptera (moths, butterflies)	
Cryptoblabes gnidiella (Millière) [Lepidoptera: Pyralidae]	Citrus pyralid
Prays citri Millière [Lepidoptera: Yponomeutidae]	Citrus flower moth
Thysanoptera (thrips)	
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips
PREDATORY MITES	
Amblydromella rhenanoides (Athias-Henriot) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius aberrans (Oudemans) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius barkeri (Hughes) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius degenerans (Berlese) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius italicus Chant [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius potentillae (Garman) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius stipulatus Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius swirskii Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite
Eryngiopus bifidus Wood [Acari: Stigmaeidae]	Stigmaeid mite
Eryngiopus siculus Vacante & Gerson [Acari: Stigmaeidae]	Stigmaeid mite
Neoseiulus californicus McGregor [Acari: Phytoseiidae]	Phytoseiid mite
Typhlodromus exhilaratus Ragusa [Acari: Phytoseiidae]	Phytoseiid mite
Typhlodromus talbii Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite
Zetzellia collyerae (Gonzalez-Rodriguez) [Acari: Stigmaeidae]	Stigmaeid mite
Zetzellia graeciana Gonzales [Acari: Stigmaeidae]	Stigmaeid mite
Zetzellia mali (Ewing) [Acari: Stigmaeidae]	Stigmaeid mite
PATHOGENS	
Fungi	
Nematospora coryli Peglion	Dry rot of fruit*
Phoma tracheiphila (Petri) L.A. Kantachveli & Gikachvili	Mal secco
Phytophthora palmivora (E.J. Butler) E.J. Butler	Brown rot*
Phytophthora syringae (Kleb.) Kleb.	Brown rot*
Septoria citri Pass.	Septoria spot*

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

4.2.2 Risk assessments for quarantine pests

A detailed risk assessment is presented in this PRA for each of the quarantine pests identified through the process of pest categorisation. Each risk assessment involved the "assessment of the probability of entry, establishment or spread" and "assessment of consequences" as described in Section 3 – Method for Pest Risk Analysis. The unrestricted risk posed by each quarantine pest for sweet oranges from Italy 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 appropriate level of protection (ALOP) to determine which quarantine pests presented an unacceptable level of risk requiring the further consideration of risk mitigation options.

Probability estimates of entry, of establishment and of spread and estimates of associated potential consequences are supported by relevant biological information. Because of similarities in pest biology, and consequent similarities between the risk assessments for some of the pests, the descriptions below are based, where relevant, on groupings of the pests. Detailed information on each quarantine pest or pest group is provided in the data sheets in Appendix – 2.

The risk assessments were conducted on the basis of the use of standard cultivation, harvesting and packing activities in the commercial production of sweet oranges (e.g. in-field hygiene and management of pests, cleaning and hygiene during packing, and commercial quality control activities). According to information provided by MPAF, packinghouse procedures include: washing of fruit with water to eliminate surface contaminants; and waxing with anti-transpiration substances supplemented with thiabendazole or imazalil (more commonly used) or orthophenylphenol, sodium ortho-phenylphenate (SOPP) or chloro-diphenyl.

4.2.2.1 Arthropod pests

4.2.2.1.1 Pink citrus rust mite

Eriophyid mites are the smallest phytophagous mites ranging in size from 0.15 to 0.3 mm. Most of them are host specific, and cause gall formation, russeting, and leaf or shoot defoliation of host plants (Ashihara *et al*., 2004). Eriophyids are almost invisible to the naked eye and are exclusively plant feeders (Razak *et al*., 2000). Eriophyid mites are important pests of citrus fruit grown for the fresh market. Mites inhabiting citrus generally move within the tree from mature, ageing plant parts to newly formed leaves and stems, and subsequently to mature fruit.

The eriophyid mite examined in this extension of existing policy is:

- *Aculops pelekassi* (Keifer) [Acari: Eriophyidae] – pink citrus rust mite (PCRM)

Introduction and spread probability

Probability of importation

The likelihood that PCRM will arrive in Australia with the importation of sweet oranges from Italy: **High**.

- PCRM is present in citrus orchards in Italy (AAN, 1998).
- Since citrus is a perennial plant that flushes continuously in subtropical and tropical regions of the world, eriophyid mites inhabiting citrus generally move within the tree

from mature, aging plant parts to newly formed leaves and stems and subsequently to mature fruit (Seki, 1981).

- Eggs are laid on the surface of leaves, fruit and green twigs (Childers *et al*., 2004).
- The small size of these mites makes them difficult to detect (Ashihara *et al*., 2004). PCRM disperses from the leaves to the fruit (Ashihara *et al*., 2004).
- The presence of fruit with typical symptoms of mite infestation (Burditt & Reed, 1963) increases the likelihood of down grading of fruit during packinghouse procedures.
- Standard post-harvest practices for export of sweet oranges will minimise the occurrence of PCRM on the fruit. However, mites may occur in the calyx where they may not be detected during pre-export inspection.
- PCRM can survive packinghouse procedures. For example, AQIS inspectors have intercepted eriophyid mites on citrus fruit imported from California into Australia.

Probability of distribution

The likelihood that PCRM will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- Adults or nymphs may remain on the surface of the fruit during distribution via wholesale or retail trade.
- The commodity may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Eriophyid mites disperse passively on air currents from one host plant to another (Lindquist & Oldfield, 1996).
- Dispersal of these slow moving mites is by wind, water, birds, insects or humans (Nielsen, 2003).
- Transfer of PCRM from fruit residues to a suitable host is a significant limiting factor in its distribution. This mite is slow moving (Nielsen, 2003) and has a restricted host range (Childers *et al*., 2004). The limited ability of eriophyid mites to move across plant surfaces (Sabelis & Bruin, 1996) would limit PCRM's ability to reach a position from which it could disperse passively on air currents.

Probability of entry (importation x distribution)

The likelihood that PCRM will enter Australia as a result of trade in sweet orange fruit from Italy and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that PCRM 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**.

- PCRM is restricted to *Citrus* spp. (Childers *et al*., 2004), which are widespread in Australia.
- PCRM is established around the Mediterranean region, and in Thailand, Japan, Taiwan and Brazil (Ashihara *et al*., 2004). There are similar environments in Australia that would be suitable for its establishment.

- PCRM overwinter within the scales of citrus tree buds and lay eggs on the sprouting buds (Ashihara *et al*., 2004). The mite begins to disperse from the leaves to fruit. Population densities on fruit decrease later in the season and the adults move to their overwintering site (Ashihara *et al*., 2004).
- PCRM has short generation time and a high reproductive rate (Mijuskovic & Kosac, 1972). The life cycle of PCRM can be completed within 5–7 days during summer (Childers *et al*., 2004). Females are capable of laying up to 30 eggs (Mijuskovic & Kosac, 1972).
- PCRM is adapted to a wide range of environments (i.e. temperate, tropical and sub tropical). Similar environments (e.g. temperature, rainfall) occur both in Italy and Australia.
- Existing control programs (IPM, application of miticide or petroleum spray oil) may control PCRM. However, PCRM has developed resistance against dithiocarbamate insecticides (Ashihara *et al*., 2004).

Probability of spread

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

- The commercial crop hosts of PCRM are located in many parts of Australia. Natural barriers such as arid areas, climatic differentials and long distances exist between these areas. The long distances between the main Australian commercial citrus production areas would make unaided dispersal difficult.
- Movement of the commodity would help the dispersal of PCRM because eggs and mites can be on the fruit. Adults and immature forms may spread undetected via the movement of fruit or infested vegetative host material (Childers *et al*., 2004).
- Individual eriophyid mites rely on wind currents, animals and orchard workers for dispersal (Mijuskovic, 1973).
- Natural predators may be able to attack PCRM but there is no evidence that they would have an effect on its spread.

Probability of entry, of establishment and of spread

The overall likelihood that PCRM will enter Australia as a result of trade in sweet oranges from Italy, 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 probabilities of entry, of establishment and of spread using the matrix of ‘rules’ for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of PCRM: **Moderate**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — PCRM is capable of causing direct harm to its hosts. PCRM cause cosmetic damage to citrus fruit (Tono *et al*., 1978; Mijuskovic & Velimirovic, 1971) and fruit destined for fresh market would be down graded during packinghouse procedures. PCRM causes russeting of leaves and mild to severe distortion of new growth, chlorosis and leaf drop (Burditt & Reed, 1963).
Any other aspects of the	**A** — There are no known direct consequences of PCRM on the natural or urban

Criterion	Estimate
environment	environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**D** — Programs to minimise the impact of this mite on host plants are likely to be costly and include insecticide applications and crop monitoring. Existing control programs may not be effective as this mite has developed resistance against dithiocarbamate insecticides (Ashihara *et al*., 2004).
Domestic trade	**C**— The presence of PCRM in commercial production areas may have a significant effect at the local level due to any resulting interstate trade restrictions on citrus fruit. These restrictions could lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	**C**— The presence of PCRM in commercial production areas on a range of commodities could have a significant effect at the district level due to any limitations to access to overseas markets where this pest is absent.
Environment	**A** — Pesticides required to control PCRM are estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for PCRM, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Low**.

4.2.2.1.2 Citrus red mite

Spider mites primarily feed on mature leaves and cause visible white stippling, mesophyll collapse and leaf drop. These mites often occur at low levels in their natural environment. They are most common on the upper surface of recently matured leaves, and all stages of the mites orient themselves along the mid-vein. As populations increase, they move to leaf margins and fruit (Childers *et al*., 2004). Spider mites feed primarily on mature leaves and differ from rust mites by feeding on tissue beneath the epidermal layer of cells. They are capable of removing cellular contents, causing cell destruction and reducing photosynthesis.

The spider mite examined in this extension of existing policy is:

- **Panonychus citri* Koch [Acari: Tetranychidae] – citrus red mite.

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

Introduction and spread probability

Probability of importation

The likelihood that citrus red mite (CRM) will arrive in Western Australia with the importation of sweet oranges from Italy: **High**.

- CRM is reported on citrus in Italy (AAN, 1998).
- CRM attacks all species of citrus, but prefers sweet oranges. Several varieties of lemon, clementines and hybrids are affected equally (Izquierdo *et al*., 2002).
- CRM feeds on fruit, foliage and young branches. It is found on both surfaces of leaves but is considered to feed primarily on the upper surfaces (Jones & Parrella, 1984).

- If populations are low, CRM is mainly found in the upper parts of trees, where there is strong sunlight. When populations are high, CRM can be found over the entire tree, on leaves, fruits and twigs (Izquierdo *et al*., 2002).
- CRM lays eggs most commonly on the leaves and on green succulent twigs. Egg laying on leaves generally occurs on the upper side, along the midrib and frequently on the petiole (Childers & Fasulo, 1995).
- Feeding by nymphs and adults produces tiny grey or silvery spots on leaves and fruit (Davidson & Lyon, 1987).
- The presence of fruit with typical symptoms of mite infestation increases the likelihood of detection of infested fruit during pre-export inspection. However, mites may occur in the calyx where they may not be detected during pre-export inspection.
- Spider mites are known to be associated with citrus fruit. AQIS inspectors have intercepted Tetranychid mites on citrus imported into Australia from various countries (PDI, 2003).

Probability of distribution

The likelihood that CRM will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- Adults or nymphs may remain on the surface of the fruit during distribution via wholesale or retail trade.
- The commodity may be distributed throughout Western Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- CRM has the ability to 'balloon' from plant to plant on silken threads (Lawson *et* al., 1996).
- It is unlikely that CRM will disperse from fruit residues to a host plant, as there is little wind in indoor environments or close to ground situations to assist its dispersal by 'ballooning'.

Probability of entry (importation x distribution)

The likelihood that CRM will enter Western Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that CRM 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.**

- CRM has a wide host range including citrus, apple, pear, peach, plum, carambola, papaya, loquat and grapevines (Bolland *et al*., 1998). Hosts of CRM are widespread in Western Australia.
- CRM is already established in Sydney and Gosford in New South Wales (Smith *et al*., 1997a). Similar environments occur in Western Australia that would be suitable for establishment of this mite.
- Adult females lay 17 to 37 eggs on foliage or fruit that hatch into the larval stage after one week. Development time from egg to adult varies with temperature and humidity,

with a mean development time of 10 days at 26^{0}C and 70% relative humidity (Jeppson *et al.*, 1975).

- CRM has a short generation time. Depending on the region, 16 generations may occur within one year, with the majority of these (10-11) occurring in spring/summer (Jeppson *et al.*, 1975).
- Existing control programs (IPM, application of petroleum spray oil) may control CRM.

Probability of spread

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

- CRM has a restricted distribution in Australia and there are similar environments in Western Australia that would be suitable for its spread.
- The commercial fruit crop hosts of CRM are grown in the southwestern part of Western Australia and there are natural barriers present between some districts. It would be difficult for the mites to disperse from one district to another by natural spread.
- CRM is more likely to disperse in association with host material. Interstate quarantine controls are in-place on the movement of nursery stock. However, these controls would have no effect on the spread of CRM on nursery stock within Western Australia.
- Spider mites do not have wings, and are therefore limited in their ability to disperse. Mites travel short distances by crawling, but depend on wind for long distance dispersal (Jeppson *et al.*, 1975).
- Dispersal of these mites within and between orchards, if in close proximity, is typical of Tetranychidae in that the species utilises strands of webbing to 'balloon' with the prevailing wind (Lawson *et al*., 1996). Adults may disperse accidentally i.e. via farm machinery (Helle & Sabelis, 1985).
- The relevance of natural enemies of CRM in Western Australia is not known.

Probability of entry, of establishment and of spread

The overall likelihood that CRM will enter Western Australia as a result of trade in sweet oranges from Italy, 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 probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of CRM: **Low**

Criterion	Estimate
Direct consequences	
Plant life or health	C— CRM is capable of causing direct harm to a wide range of hosts. This includes damage in the form of chlorosis and premature leaf drop (Hall & Simms, 2003). Spider mites feed primarily on mature leaves, removing cellular contents, causing cell destruction and reducing photosynthesis (Childers *et al*., 2004).
Any other aspects of the environment	**A**— There are no known direct consequences of CRM on the natural or urban environment but their introduction into a new environment may lead to competition for resources with native species.

Criterion	Estimate
Indirect consequences	
Eradication, control, etc.	**B** — Additional programs to minimise the impact of CRM on host plants may be necessary. An appropriate miticide or biological control would be required if this pest reached high levels of infestation. CRM is present in NSW on the central coast but is not a serious pest due to effective biocontrol strategies (Smith *et al*., 1997a). If CRM became established in Western Australia, the implementation of these strategies would require significant resources at the local level.
Domestic trade	**A** — The presence of CRM in the commercial citrus production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level. It is doubtful that there would be any resulting interstate trade restrictions on host plants and plant material as CRM is present in other states.
International trade	**C** — The presence of CRM in commercial production areas of a wide range of commodities may have a significant effect at the district level due to any limitations to access to overseas markets where these pests are absent.
Environment	**A** — Pesticides required to control CRM are estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for CRM, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Very low**.

4.2.2.1.3 Yellow mite

Mites in the family Tydeidae are cosmopolitan and found in diverse habitats, including trees, shrubs, mosses and lichens (Krantz, 1978). Tydeid mites are primarily considered to be fungivores or predators but some species are known to feed on plants (Jeppson *et al*., 1975).

The tydeid mite examined in this extension of existing policy is:

- *Lorryia formosa* Cooreman [Acari: Tydeidae] – yellow mite

Introduction and spread probability

Probability of importation

The likelihood that yellow mite will arrive in Australia with the importation of sweet oranges from Italy: **High**.

- Yellow mite is reported from citrus production areas in Italy (Vacante & Gerson, 1987).
- Yellow mite primarily feeds on foliage (Vacante & Nucifora, 1986). However, if populations are high it may occur on fruit (Jeppson *et al*., 1975).
- Eggs are laid under the sepals and fruit peduncles (Jeppson *et al*., 1975) and the young mites stay there after hatching as they are protected as they feed and injure the young fruit tissues (Jeppson *et al*., 1975). This injury results in a ring of dead brown tissue, which enlarges as the fruit grows (Jeppson *et al*., 1975).

- Standard post-harvest practices for export of sweet oranges will minimise the occurrence of yellow mites on the fruit but yellow mites beneath the calyx would remain with the fruit.
- Fruit with rind damage may be detected during pre-export inspections. However, yellow mites beneath the calyx may not be detected during pre-export inspections.
- Tydeid mites can survive packinghouse procedures. AQIS inspectors have intercepted tydeid mites on citrus (PDI, 2003).

Probability of distribution

The likelihood that the yellow mite will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- Adults or nymphs may remain on the surface of the fruit during distribution via wholesale or retail trade.
- The commodity may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Transfer of the yellow mite from discarded fruit waste to a suitable host is a significant limiting factor in its distribution. Unassisted movement of the immature and mature stages occurs within the canopy of host plants (Jeppson *et al*., 1975).
- Because all stages of the yellow mite survive in the environment for some time and because it has a wide host range, it may transfer to a susceptible host.

Probability of entry (importation x distribution)

The likelihood that the yellow mite will enter Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that the yellow mite 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**.

- Yellow mite has a wide host range including avocado (Jeppson *et al*., 1975) and citrus (Aguilar & Childers, 2000). These hosts are wide spread in Australia.
- Yellow mite has been reported from Argentina, Brazil, Chile, Portugal, Spain, Uruguay and Florida in the USA (Jeppson *et al*., 1975; Aguilar & Childers, 2000). There are similar environments to these areas in Australia that would be suitable for its establishment.
- Mediterranean type climates in parts of Australia would favour the establishment of the yellow mite, given its wide distribution in areas with Mediterranean type climates (Aguilar & Childers, 2000). Tydeid mite populations can build up to high levels during hot, dry summers (Tomkins *et al*., 2000).
- Abundance of host plants would favour the development of high population densities of the yellow mite in Mediterranean type climatic zones in Australia.
- Existing control programs may be effective. *Lorryia formosa* is susceptible to sulphur sprays and dusts or to the specific acaricides used to control tetranychid mites (Jeppson *et al*., 1975).

Probability of spread

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

- Movement of commodities would help the dispersal of the yellow mite because it could potentially be on fruit.
- Physical barriers may prevent long-range spread of the yellow mite. However, if the yellow mite was to be introduced to production areas, physical barriers are unlikely to be a limiting factor in its spread.
- The wide host range of the yellow mite and the occurrence of other host plants between commercial fruit orchards in Australia would aid the spread of this mite.
- Natural predators may be able to attack the yellow mite but there is no evidence that they would have an effect on its spread.

Probability of entry, of establishment and of spread

The overall likelihood that the yellow mite will enter Australia as a result of trade in sweet oranges from Italy, be distributed in a viable state to suitable hosts, establish in the area and subsequently spread within Australia: **Low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of the yellow mite: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — The yellow mite occurs on a variety of crops throughout the world and has been reported to cause injury to citrus fruit (Jeppson *et al*., 1975).
Any other aspects of the environment	**A**— There are no known direct consequences of the yellow mite on the natural or urban environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**B** — Existing control programs may be effective as the yellow mite is susceptible to sulphur sprays and dusts and to the specific acaricides used to control tetranychid mites (Jeppson *et al*., 1975).
Domestic trade	**C** — The presence of the yellow mite in commercial production areas may have a highly significant effect at the local level due to any resulting interstate trade restrictions on a wide range of commodities.
International trade	**A** — The presence of the yellow mite in the commercial production areas of a range of commodities (citrus, avocados) is unlikely to be discernable at the district level as there are no known limitations for access to overseas markets where this pest is absent.
Environment	**A** — Additional pesticide applications or other control activities may be required to control this pest on susceptible crops but any impact on the environment is unlikely to be discernible at the local level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for the yellow mite, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Very low**.

4.2.2.1.4 Mediterranean fruit fly

Mediterranean fruit fly (Medfly) is one of the world's most destructive fruit pests. Because of its wide distribution around the world, its ability to tolerate colder climates and its wide range of hosts, it is ranked one of the most economically important fruit fly species (Thomas *et al*., 2001; White & Elson-Harris, 1994). Medfly is widely distributed in Europe, Africa and South America. It is present in the State of Western Australia but is absent and subject to official control to prevent its entry into other Australian States and Territories.

The fruit fly examined in this extension of existing policy is:

- *Ceratitis capitata* (Wiedemann) [Diptera: Tephritidae] – Mediterranean fruit fly.

Introduction and spread probability

Probability of importation

The likelihood that Medfly will arrive in Australia with the importation of sweet oranges from Italy: **High**.

- Medfly has been reported in Italy (EPPO, 2002). Medfly is known to infest and damage a wide range of fruit crops. In Mediterranean countries, it is particularly damaging on citrus and peaches.
- Medfly is known to be associated with the citrus fruit pathway. Eggs are laid under the skin of fruit (Christenson & Foote, 1960). Larvae feed and develop within the fruit until ready to pupate in the soil (Knapp, 1998).
- Medfly larvae are internal feeders and may not be readily detected by on-arrival inspection (Fimmiani, 1989).
- The potential for infested fruit to decay (Cayol *et al*., 1994) increases the likelihood of detection of infested fruit during inspection. However, the presence of only eggs in the fruit reduces the likelihood of detection during inspection.

Probability of distribution

The likelihood that Medfly will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Moderate**.

- The commodity may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Eggs may develop into larvae within fruit throughout the distribution chain. Wholesalers, retailers or consumers could discard spoiled fruit containing eggs or larvae.
- In order for this species to transfer to a host, the larvae must develop within the discarded sweet orange fruit, pupate, emerge, mate and then find a suitable host with mature fruit in which to lay eggs.

Probability of entry (importation x distribution)

The likelihood that Medfly will enter the PRA area as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Moderate**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that Medfly 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.**

- Medfly is polyphagous, feeding on the fruit of many plants such as citrus, peach, pear, apple, apricot, fig, plum, kiwifruit, quince, grape, sweet cherry, pomegranate and strawberry. Host preferences vary from region to region depending on what fruits are available (White & Elson-Harris, 1994).
- Hosts are widely distributed throughout Australia, both in commercial orchard districts and suburban areas.
- Mediterranean type climates that favour the establishment of Medfly occur in various parts of Australia.
- Medfly is already established in areas of Western Australia. The largest populations occur in the Perth metropolitan area and in towns in the south west of the State (Woods, 1997).
- All other States of Australia are free of Medfly. Small, isolated outbreaks have occurred in the city of Adelaide in South Australia and the Northern Territory due to the illegal movement of infested fruit by humans. These incursions were quickly detected by the extensive fruit fly surveillance network in Australia and contained and rapidly eradicated through the use of established containment and eradication procedures (Meats *et al.*, 2003).
- Development of Medfly is principally dependent on temperature. The optimum temperature for development is 32°C, which enables completion of a generation within 2 weeks. The number of generations per year depends on temperature, ranging from 4-5 to 12-13 in tropical and subtropical regions (Fletcher, 1989). In southern Italy, 6 to 7 generations per year have been reported (HYPP, 2004b).
- Females lay 3 to 7 eggs in clusters, about 2 to 5 mm deep inside the fruit. Under optimum conditions, the female may lay 500 to 600 eggs during her life (HYPP, 2004b). Multiple ovipositions by different females can occur, result in many larvae developing in the same fruit (Thomas *et al*., 2001). During warm weather, eggs hatch in 1.5 – 3 days. Larvae feed and develop within the fruit until ready to pupate in the soil (Thomas *et al*., 2001).
- Females will not lay eggs when temperatures drop below 16°C except when exposed to sunlight for several days. Development in egg, larval and pupal stages stop at 10^0C (Thomas *et al*., 2001).
- Medfly can survive the winter in both adult and immature stages (De Lima, 1998). Pupae carry the species through unfavourable conditions. In southern Italy, a small number of adults may survive on late-season orange trees (HYPP, 2004b). In Australia, adults may over-winter in host trees (Smith *et al*., 1997a).

Probability of spread

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

- Medfly has a wide host range (Thomas *et al*., 2001) and a wide tolerance to environmental conditions and without appropriate controls may spread within Australia.
- Medfly is under official control in Australia to prevent its spread from Western Australia into other States (De Lima *et al*., 1993).
- There are restrictions in place in Australia on the movement of fruit to prevent the spread of fruit flies, including Medfly.
- Movement of infested fruit can spread Medfly to previously uninfested areas (Thomas *et al*., 2001; Meats *et al*., 2003). Occasional, isolated, small outbreaks occur in the city of Adelaide in South Australia and in the Northern Territory due to the illegal movement of infested fruit by humans.
- Established detection (including a national fruit fly trap surveillance network), containment and eradication procedures in place in Australia for Medfly have been used previously to control its spread when outbreaks occur (Meats *et al*., 2003).

Probability of entry, of establishment and of spread

The overall likelihood that Medfly will enter Australia as a result of trade in sweet oranges from Italy, 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 probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of the Medfly: **High**.

Criterion	Estimate
Direct consequences	
Plant life or health	**D** — Medfly is polyphagous and the most serious fruit fly pest in Mediterranean environments (Christenson & Foote, 1960). It is capable of causing significant reductions in the production of marketable fruit.
Any other aspects of the environment	**B** — Fruit flies introduced into a new environment will compete for resources with the 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.
Indirect consequences	
Eradication, control, etc.	**E** — Programs to control/eradicate this pest from areas in Australia would be costly. For example, the cost of eradication of Medfly is estimated at AU$70m for Western Australia and US$20m for Florida. In 1995, the papaya fruit fly eradication program, using male annihilation and protein bait sprays, cost AU$ 34 million (QDPI, 2003). The potential economic risk associated with Medfly is considerable, with an endemic infestation in California estimated to cost in excess US$ 1 billion per annum (Siebert, 1994). Over US$ 350 million has already been spent to prevent Medfly becoming established in California (Metcalf, 1995). Increases in the existing monitoring programs would also be costly.
Domestic trade	**D** — The presence of fruit flies in commercial production areas has a significant effect at the regional level due to interstate trade restrictions on a wide range of commodities.
International trade	**D** — The major risk for Australia arises from the imposition of additional phytosanitary restrictions on fruit exports should Medfly become established, even temporarily, in areas currently free of this pest. When the papaya fruit fly

Criterion	Estimate
	outbreak occurred in northern Queensland, Australia experienced trade restrictions that affected the whole country.
Environment	**A** — Although additional pesticide applications or other control activities would be required to control these pests on susceptible crops, any impact on the environment is unlikely to be discernible.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for the Medfly, determined by combining the overall 'probability of entry, of establishment, and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Moderate**.

4.2.2.1.5 Citrophilus mealybug

Mealybugs injure plants by extracting sap and produce honeydew that serves as a substrate for the development of sooty moulds. Sooty moulds on leaves interfere with photosynthesis (Walker & Aitken, 1985) and may lower fruit quality (Soto *et al*., 2002). Mealybugs generally prefer warm, humid, sheltered sites away from adverse environmental conditions and natural enemies. Many mealybug species pose particularly serious problems to agriculture when introduced into new areas of the world without their specific natural enemies (Miller *et al*., 2002).

The mealybug species examined in this extension of existing policy is:

- * *Pseudococcus calceolariae* Maskell [Hemiptera: Pseudococcidae] – citrophilus mealybug.

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

Introduction and spread probability

Probability of importation

The likelihood that citrophilus mealybug will arrive in Western Australia with the importation of sweet oranges from Italy: **High**.

- Citrophilus mealybug has been reported on citrus in Italy (AAN, 1998).
- Mealybugs usually live around the calyx of the fruit from flowering onwards. They generally remain anchored to the host. Therefore, they may be difficult to detect on fruit during sorting, especially at low population levels (Taverner & Bailey, 1995).
- Routine packinghouse procedures (washing, waxing and grading) may not remove all mealybugs from around the calyx. This is particularly true of adult females and/or nymphs that have found protective spaces around the calyx or are protected by waxy cocoons.
- Mealybugs can survive packinghouse procedures. AQIS inspectors have intercepted mealybugs on citrus imported from California into Australia (PDI, 2003).

Probability of distribution

The likelihood that citrophilus mealybug will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Moderate**.

- Adults or immature forms may remain on the surface of the fruit during distribution via wholesale or retail trade.
- The commodity may be distributed throughout Western Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Mealybugs are likely to survive storage and transportation. For example *Pseudococcus affinis* can survive up to 42 days storage at 0°C (Hoy & Whiting, 1997).
- Citrophilus mealybug may enter the environment as adults discarded with fruit or as juveniles blown by wind or carried by other vectors.
- Adult females are wingless and would need to be carried onto hosts by vectors such as humans or insects. Adult females can only crawl a few metres, restricting their ability to move from discarded fruit waste to a suitable host.
- Adult males are winged, capable of short flights and are short lived. Male dispersal by crawling or flight is strongly affected by the location of females and their production of sex pheromones.
- Because all stages of mealybugs may survive in the environment for some time and because they are polyphagous, they could be transferred to a susceptible host.

Probability of entry (importation x distribution)

The likelihood that citrophilus mealybug will enter Western Australia as a result of trade in sweet citrus from Italy and be distributed in a viable state to the endangered area: **Moderate**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that citrophilus mealybug 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**.

- Citrophilus mealybug is endemic to eastern Australia and is also reported in the USA, South America, New Zealand, South Africa and Europe (Smith *et al*., 1997a).
- Citrophilus mealybug is a highly polyphagous species that has been recorded on 40 plant families (Ben-Dov, 1994) and these hosts are widespread in Western Australia.
- Mealybug development is temperature dependent. There is a minimum threshold temperature for each species of mealybug, below which development either ceases or is slowed significantly. There is also a maximum threshold temperature, beyond which development is slowed significantly or ceases all together. If temperatures remain elevated for prolonged periods, mortality increases significantly.
- Mild to warm conditions are most favourable with temperatures of about 25°C and a high relative humidity being optimum for mealybug development.
- Mealybugs have high reproductive capabilities with multiple generations possible per year (Smith *et al*., 1997a). Mature females commonly move to a protected site to lay eggs over a period of up to 2 weeks. Females lay approximately 500 eggs and these hatch within a few days. Females cease feeding before egg laying and die at the end of egg laying.
- Modelling studies in Western Australia suggest that certain regions within Western Australia are suitable for the establishment of this pest.

- Control strategies are already in place as Western Australia has several economically important mealybug species. These existing control strategies would minimise the impact of the citrophilus mealybug within Western Australia. Biological control agents are available that provide control of citrophilus mealybug.

Probability of spread

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

- The main long-range dispersal mechanism for Citrophilus mealybug is through the movement of nymphs and adults on infested host material, such as fruit and nursery stock.
- Although quarantine controls are in place on the movement of nursery stock into Western Australia, these controls would have no effect on the spread of citrophilus mealybug within Western Australia.
- Citrophilus mealybug is a highly polyphagous species that has been recorded on 40 plant families (Ben-Dov, 1994) and these hosts are widespread in Western Australia.
- Commercial fruit crop hosts of citrophilus mealybug are grown in southwestern Western Australia and there are natural barriers between some districts. It would be difficult for the mealybugs to disperse from one district to another by natural means.
- Female mealybugs do not have wings and are therefore limited in their ability to disperse. However, the spread of this pest would be aided if other host plants occurred between the commercial fruit orchards in different districts of Western Australia.
- Short-range dispersal of juveniles could occur through the movement of crawlers in wind currents or as contaminants on biological or mechanical vectors (Williams, 1996).
- Adult males are winged, capable of short flights and are short lived. Male dispersal by crawling or flight is strongly affected by the location of females and their production of sex pheromones.
- Natural enemies of the citrophilus mealybug, such as *Cryptolaemus montrouzieri* and the parasitoids *Tetracnemus pretisous* and *Coccophagus gurneyi*, are used to control this pest in Australia and other countries. However, only *Cryptolaemus montrouzieri* is known to be present in Western Australia.

Probability of entry, of establishment and of spread

The overall likelihood that the citrophilus mealybug will enter Western Australia as a result of trade in sweet oranges from Italy, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Moderate**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of the citrophilus mealybug: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — Citrophilus mealybug is capable of causing direct harm to a wide range of hosts (Hely *et al.*, 1982). Fruit quality can be reduced by the presence of sooty mould. The citrophilus mealybug is highly polyphagous and host plants are

Criterion	Estimate
	common in Western Australia.
Any other aspects of the environment	**A** — There are no known direct consequences of citrophilus mealybug on the natural or built environment but its introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**B** — Control strategies are already in place as Western Australia has several economically important mealybug species. These existing control strategies would minimise the impact of the citrophilus mealybug within Western Australia.
Domestic trade	**A** — The presence of citrophilus mealybug in the commercial citrus production areas of Western Australia is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level. It is doubtful that there would be any resulting interstate trade restrictions on host plants and plant material as these mealybugs are present in other States.
International trade	**A** — The presence of citrophilus mealybug in the commercial citrus production areas in Western Australia would not have a significant effect, as the mealybug is widespread in areas other than Western Australia.
Environment	**A** — Additional pesticide applications or other control activities may be required to control these pests on susceptible crops but any impact on the environment is unlikely to be discernible at the local level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for citrophilus mealybug, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Low**.

4.2.2.1.6 Scales

Scale insects are primarily sedentary, small and often inconspicuous and have been spread widely on plants and plant products. Scales are present in most citrus production areas of the world. A wax-based covering protects armoured scales.

The scales examined in this extension of existing policy are:

- *_Chrysomphalus dictyospermi_ (Morgan) [Hemiptera: Diaspididae] – palm scale
- *_Lepidosaphes gloverii_ (Packard) Hemiptera: Diaspididae] – Glover's scale
- *_Parlatoria pergandii_ Comstock [Hemiptera: Diaspididae] – chaff scale
- _Parlatoria ziziphi_ (Lucas) [Hemiptera: Diaspididae] – black parlatoria scale
- _Unaspis yanonensis_ (Kuwana) [Hemiptera: Diaspididae] – arrowhead scale

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

Introduction and spread probability

Probability of importation

The likelihood that scales will arrive in the PRA area with the importation of sweet oranges from Italy: **High**.

- These scales have been reported as being present on citrus in Italy (AAN, 1998).

- These scales feed on fruit (Timmer & Duncan, 1999), and it is likely that fruit sent to be packed for export will be infested by some of these scales as field control practices may not give complete control (Taverner & Bailey, 1995).
- *Parlatoria ziziphi* feeds almost exclusively on citrus. High numbers of this pest may occur on fruit (Fasulo & Brooks, 2001).
- *Parlatoria pergandii* feeds on fruit tissue, which sometimes leads to fruit abscission (Davies & Albrigo, 1994).
- *Unaspis yanonensis* feeds almost exclusively on citrus (Ohkubo, 1980) and is more severe on fruit and leaves resulting in delayed colour development (Davies & Albrigo, 1994).
- Scales are difficult to remove from fruit during cleaning due to their protective covers. *Parlatoria ziziphi* can be firmly attached to the fruit and may not be removed during packinghouse procedures.
- Routine washing procedures (washing, waxing and grading) may not remove all scales from the fruit surface. Armoured scales are unlikely to be killed by the washing solution, as the physical properties of their protective covers provide an effective barrier against contact toxicants (Foldi, 1990).
- Scales are known to be associated with citrus fruit and have been intercepted by AQIS inspectors on citrus imported from California into Australia (PDI, 2003).

Probability of distribution

The likelihood that scales will be distributed to the endangered area as a result of the processing, sale or disposal of sweet orange from Italy: **Low**.

- Adults or immature forms may remain on the surface of the fruit during distribution via wholesale or retail trade.
- Adults or immature forms are likely to survive storage and transport and be associated with infested waste.
- The commodity may be distributed throughout the PRA area for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- The natural dispersal mechanism that allows for the movement of scale species from discarded fruit waste to a suitable host is a significant limiting factor in their distribution. Scales are only active during the first instar (or crawler) stage and only travel short distances to a new plant. First instars (crawlers) would have to be present for the scale to move from waste material to a host plant.

Probability of entry (importation x distribution)

The likelihood that scales will enter the PRA area as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that 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**.

- Some of these scales are polyphagous (*Chrysomphalus dictyospermi*, *Lepidosaphes gloverii* and *Parlatoria pergandii*) and have shown the ability to adapt to new hosts and environments (McClure, 1983; Schvester, 1985; Hanks & Denno, 1994).
- Although the precise climate tolerance of scales is unknown, they are considered to be tropical or subtropical pests, and are therefore less likely to establish in either cool or hot and dry climates.
- A range of plants commonly found in the PRA area can act as hosts for these species, including *Citrus* spp., *Severinia buxifolia, Murraya paniculata*, *Cocos nucifera, Mangifera indica* and *Nipa* spp.
- Scales have a high reproductive rate with an average three to seven generations per year has been reported. The generation time is much longer during colder weather (Fasulo & Brooks, 2001).
- *Parlatoria ziziphi* is reported to have 2-4 generations per year with females producing approximately 30 eggs (Sweilem *et al*., 1984).
- *Unaspis yanonensis* is reported to have three generations per year (Nohara, 1962) with females producing 40 – 165 eggs (Huang *et al*., 1983). It overwinters in the second instar or pupal stage in males and in the second instar or adult stage in females (Huang *et al*., 1983).
- *Parlatoria ziziphi* has established and been eradicated in the Northern Territory. Some scale species (*Chrysomphalus dictyospermi*, *Lepidosaphes gloverii* and *Parlatoria pergandii*) are already established in parts of Australia, indicating that suitable environments for their establishment are available in the PRA area.
- Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not necessarily all hosts.

Probability of spread

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

- Adults and nymphs 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).
- Spread by active movement and wind-accomplished dispersal is by first-instar crawlers. Birds, insects and other animals may act as vectors (Beardsley & Gonzalez, 1975). Subsequent instars are sessile.
- The commercial fruit crop hosts of the scales are located in many parts of Australia. Natural barriers such as arid areas, climatic differentials and long distances exist between these areas. The long distances between commercial host crops in Australia would make it difficult for the scales to disperse by natural spread.
- Some scale species (*Chrysomphalus dictyospermi*, *Lepidosaphes gloverii* and *Parlatoria pergandii*) are already recorded in Australia (AICN, 2004) but are absent from Western Australia. There are similar environments in Western Australia that would be suitable for their spread.

- Australia has a wide climate range and many areas are suitable for the establishment and spread of scales. Low humidity and high temperatures limit the spread of *Parlatoria* spp. (Gerson, 1980).
- Adult males are short-lived, winged and capable of weak flight. They lack functional mouthparts and cannot feed. Longevity of this stage generally is limited to a few hours (Beardsley & Gonzalez, 1975).
- Short-range dispersal can occur though the movement of first instar crawlers in wind currents or by biological or mechanical vectors (Willard, 1974).
- Several natural enemies that attack scales occur in the PRA area.

Probability of entry, of establishment and of spread

The overall likelihood that scales will enter the PRA area as a result of trade in sweet oranges from Italy, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within the PRA area: **Low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

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

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — Scales can cause direct harm to a wide range of plant hosts (Williams & Watson, 1988). Damage to fruit produces green spots and such fruit is downgraded for the fresh market (Beardsley & Gonzalez, 1975; Brooks & Knapp, 1983). These scales are highly polyphagous and host plants are widely distributed in Australia.
Any other aspects of the environment	**A** — Scales introduced into a new environment will compete for resources with the 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.	**C** — Additional programs to minimise the impact of these pests on host plants may be necessary. Existing control programs may be effective for some hosts but not all hosts.
Domestic trade	**B** — The presence of these scales in commercial production areas may have an effect due to any resulting interstate trade restricted on a wide range of commodities.
International trade	**B** — The presence of these pests in commercial production areas of a range of commodities may have an effect due to possible limitations to access to overseas markets where these pests are absent.
Environment	**A** — Although additional applications or other control activities would be required to control scales on susceptible crops, any indirect effect on the environment is unlikely to be discernible.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for scales, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Very low**.

4.2.2.1.7 Whiteflies

Whiteflies in sufficient numbers can lead to sooty mould development. Sooty moulds on leaves interfere with photosynthesis (Walker & Aitken, 1985) and may lower fruit quality (Soto *et al*., 2002).

The whiteflies examined in this extension of existing policy are:

- *Aleurothrixus floccosus* (Maskell) [Hemiptera: Aleyrodidae] – woolly whitefly
- *Parabemisia myricae* (Kuwana) [Hemiptera: Aleyrodidae] – bayberry whitefly

Introduction and spread probability

Probability of importation

The likelihood that whiteflies will arrive in Australia with the importation of sweet oranges from Italy: **High**.

- These whitefly species have been reported on citrus in Italy (AAN, 1998).
- Whiteflies are generally foliage feeders and deposit their eggs into the underside of mature leaves (Salinas *et al*., 1996).
- Eggs are rarely deposited on the fruit (Vulic & Beltran, 1977; Uygun *et al*., 1990).
- Adults fly in the morning and evening, redistributing themselves within the crop and locating leaves suitable for feeding and oviposition (Meyerdirk & Moreno, 1984).
- Honeydew produced by whiteflies on fruit may result in the development of sooty moulds (Salinas *et al*., 1996; Uygun *et al*., 1990). Fruit in this condition is likely to be detected during pre-export inspections.
- Post-harvest grading, washing and packing procedures are likely to remove many of these pests from the fruit.
- Whiteflies are known to be associated with citrus fruit and have been intercepted by AQIS inspectors on citrus imported from California into Australia (PDI, 2003).

Probability of distribution

The likelihood that whiteflies will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- Immature forms (eggs, crawlers, sessile instars) may remain on the surface of the fruit during distribution via wholesale or retail trade.
- The commodity may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Nymphs are active only during the first instar stage, becoming sedentary for the remaining nymphal instars (van Lenteren & Noldus, 1990).
- The natural dispersal mechanism that would allow the movement of whiteflies from discarded fruit waste to a suitable host could be a significant limiting factor in their distribution. Whiteflies are weak flyers and have a limited ability to direct their flight (Byrne *et al*., 1990).

Probability of entry (importation x distribution)

The likelihood that whiteflies will enter Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that whiteflies 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**.

- These whitefly species are highly polyphagous and have shown the ability to adapt to new environments (Mound & Halsey, 1978; Uygun *et al*., 1990). A range of plants commonly found in Australia can act as hosts for these species (e.g. *Citrus* spp., *Persea* spp., *Prunus* spp. and *Vitis* spp.).
- Reproduction of *Aleurothrixus floccosus* is sexual and oviposition can occur within one day of adult emergence (Paulson & Beardsley, 1986; Salinas *et al*., 1996). Reproduction of *Parabemisia myricae* is by parthenogenesis (Uygun *et al*., 1990).
- The life cycle of *Aleurothrixus floccosus* can be completed in 23–31 days, with females capable of laying up to 178 eggs (Salinas *et al*., 1996). The lifecycle of *Parabemisia myricae* can be completed in approximately 24 days, with females capable of laying up to 70 eggs (Uygun *et al*., 1990).
- In Mediterranean environments, *Aleurothrixus floccosus* reproduces almost continuously with multiple generations per year. *Parabemisia myricae* is reported to have five generations per year in California (Walker & Aitken, 1985) and up to nine generations per year in Cyprus (Orphanides, 1991).
- *Parabemisia myricae* has extended its geographical range in the past 30 years, particularly in the Mediterranean region.
- Existing control programs may be effective for some hosts but not all hosts.

Probability of spread

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

- The commercial fruit crop hosts of these pests are located in many parts of Australia. Natural barriers such as arid areas, climatic differentials and long distances exist between these areas.
- The long distances between the main orchard districts in Australia would make it difficult for these whiteflies to disperse from one area to another by natural spread. However, the highly polyphagous nature of these species may enable them to locate suitable hosts in the intervening areas.
- Movement of commodities would help disperse whiteflies. Adults and immature forms may spread undetected via the movement of fruit or infested vegetative host material (Salinas *et al*., 1996).
- Short-distance dispersal may occur, as adults are mobile and able to move between host plants (Byrne *et al*., 1990). Long-distance dispersal occurs principally through the movement of infested plants and plant products.

- Adults of *Aleurothrixus floccosus* are sluggish and seldom fly but wind, vehicles or humans could assist in their dispersal (Salinas *et al*., 1996).
- Crawlers are able to disperse within a host plant. Nymphs are mobile for a short time (van Lenteren & Noldus, 1990) and will settle along veins on the underside of leaves (Salinas *et al*., 1996).
- Most whiteflies remain on the plants on which they originated, especially if conditions remain favourable (Gerling & Horowitz, 1984).
- Environments (e.g. temperature, rainfall) similar to those in Italy occur in parts of Australia.
- A wide range of parasitoids and generalist predators attacks whiteflies but their importance in controlling whitefly populations in Australia is not known.

Probability of entry, of establishment and of spread

The overall likelihood that whiteflies will enter Australia as a result of trade in sweet oranges from Italy, 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 probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of the whiteflies: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C**— These pests cause direct damage to host plants. Sooty moulds growing on honeydew produced by whiteflies reduce photosynthesis and productivity (Salinas *et al*., 1996; Uygun *et al*., 1990). *Parabemisia myricae* is a damaging pest of citrus in California (Rose & Rosen, 1991), Turkey (Sengonca *et al*., 1993) and Israel (Swirski *et al*., 1985). In Florida, *Parabemisia myricae* has been recorded damaging citrus seedlings (Hamon, 2001). In Turkey, *P. myricae* has been shown to transmit citrus chlorotic dwarf virus (Korkmaz *et al*., 1996).
Any other aspects of the environment	**A**— There are no known direct consequences of whiteflies on the natural or urban environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**C** — Additional programs to minimise the impact of these pests on host plants may be necessary. Existing control programs may 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).
Domestic trade	**C** — 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 could lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	**C** — The presence of these pests in commercial production areas on a range of commodities may have a significant effect at the district level due to any limitations to access to overseas markets where these pests are absent.
Environment	**A** — Pesticides required to control whiteflies are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the local level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for whiteflies, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Very low**.

4.2.2.1.8 Citrus Pyralid

Citrus pyralid is native to the Mediterranean region, able to feed on almost any plant and most often found on commercial crops. Citrus pyralid is a cosmopolitan species in warm climates but is unable to survive winters in cooler, temperate areas into which it may be imported with produce (Carter, 1984). This species has been intercepted in Denmark, Finland, the Netherlands, Norway, Sweden and the United Kingdom on imported material (Karsholt, 1996).

The citrus pyralid examined in this extension of existing policy is:

- *Cryptoblabes gnidiella* Millière [Lepidoptera: Pyralidae] – citrus pyralid

Introduction and spread probability

Probability of importation

The likelihood that citrus pyralid will arrive in Australia with the importation of sweet oranges from Italy: **Moderate**.

- Citrus pyralid has been recorded as being present on citrus in Italy (AAN, 1998).
- Eggs are laid on the fruit and the foliage (Carter, 1984). Larvae feed mainly on fruit but also feed on foliage (Liotta & Mineo, 1964). Pupation takes place on the host plant or on the ground (Swirski *et al*., 1980).
- Fully grown larvae of the citrus pyralid are 12 mm long (Singh & Singh, 1995) and are likely to be detected during pre-export inspections.
- Larvae of citrus pyralid are often found in association with infestations by other pests, for example on citrus with *Planococcus citri* and on grapes following attack by the European vine moth, *Lobesia botrana* (Carter, 1984).
- Post harvest rots can develop on infested fruits and such fruit may be detected during pre-export inspections.
- Routine packinghouse procedures (washing, waxing and grading) may not remove all citrus pyralids from the fruit.

Probability of distribution

The likelihood that citrus pyralid will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- The commodity may be distributed throughout Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Citrus pyralid may enter the environment via adult emergence from pupae in waste that has been discarded before the fruit desiccates or decays. The larvae and pupae may survive cool storage employed by the wholesalers and retailers.
- If adult moths were to survive cold storage, they could enter the environment by flight from fruit at the point of sale, during transportation of purchased fruit from retailers to households and from discarded fruit at landfills.

- The natural dispersal stage for this lepidopteran is the adult.
- Early instar larvae that have escaped detection during inspection would be unlikely to develop in discarded fruit before the fruit desiccates or decays.
- The larvae would also be unlikely to find a suitable host on which to complete their development.

Probability of entry (importation x distribution)

The likelihood that citrus pyralid will enter Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that citrus pyralid 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**.

- Citrus pyralid is highly polyphagous, often being found on commercial crops including citrus (Silva & Mexia, 1999), coffee and tropical fruits (Wysoki, 1986; Hashem *et al*., 1997), apple (Carter, 1984), banana (de Jager & Daneel, 1999), avocado (Ascher *et al*., 1983) and *Prunus* spp. and grapes (Carter, 1984). These hosts are widely distributed in Australia.
- The life cycle of the citrus pyralid can be completed in 28 days, depending on temperature. Females are capable of laying up to 100 eggs. Three to four generations per year have been reported in southern Italy, up to five in North America (Carter, 1984) and nine in India (Singh & Singh, 1995). The pre-ovipositional period lasts a full day after mating, with most eggs laid during the first night (Wysoki *et al*., 1993).
- Citrus pyralid is likely to adapt to Australian conditions, given its wide distribution in Mediterranean regions.
- Existing control programs may be effective for some hosts but not all hosts.

Probability of spread

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

- The long distances between the main Australian commercial orchard districts would make it difficult for the citrus pyralid to disperse directly from one area to another by natural spread. However, the polyphagous nature of this species may enable it to locate suitable hosts in the intervening areas.
- Short-distance dispersal occurs as adult moths are mobile and able to rapidly move between host plants.
- Environments (e.g. temperature, rainfall) similar to those in the Mediterranean region occur in parts of Australia.
- The relevance of natural enemies to the spread of the citrus pyralid in Australia is not known.

Probability of entry, of establishment and of spread

The overall likelihood that citrus pyralid will enter Australia as a result of trade in sweet oranges from Italy, 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 probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of the Citrus pyralid: **Moderate**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — Citrus pyralid is capable of causing direct damage to a range of host plants. Larval feeding on foliage and fruits causes direct crop losses. It is an important pest in fruit orchards in the Mediterranean region, including citrus, avocado, grape, loquat and pomegranate (Balachowsky, 1972). The losses caused by this pest are not quantified in the literature, although combined losses of macadamia nuts in Israel as a result of *Cryptoblabes gnidiella*, *Apomyelois ceratoniae* and *Cryptoblabes leucotreta* amounted to 30% (Wysoki, 1986). Serious damage on hybrid sorghum has been reported from India (Singh & Singh, 1995).
Any other aspects of the environment	**A** — Citrus pyralid introduced into a new environment will compete for resources with native species. It is 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.	**D** — Programs to minimise the impact of this pest on host plants are likely to be costly and include pesticide applications and crop monitoring. A control program would have to be implemented in infested orchards to reduce fruit damage and yield losses, thereby increasing production costs. Eradication and control would be significant at the regional level. Citrus pyralid may potentially increase production costs by triggering specific control measures requested by trading partners.
Domestic trade	**C** — The presence of citrus pyralid in commercial production areas may have a highly significant effect at the local level due to any resulting interstate trade restrictions on a wide range of commodities.
International trade	**D** — The presence of this pest in the commercial production areas of a range of commodities (citrus, grapes, avocados, sorghum and rice) may have a significant effect at the regional level due to any limitations to access to overseas markets where this pest is absent. These restrictions may lead to a loss of markets, which in turn would be likely to require industry adjustment.
Environment	**A** — Pesticides required to control the citrus pyralid are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the local level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for citrus pyralid, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Low**.

4.2.2.1.9 Citrus Flower Moth

The citrus flower moth is widespread in the Mediterranean region and it is also reported from some countries in Africa. Reports by the European Plant Protection Organization (EPPO) of citrus flower moth on citrus from the east of Turkey, the Middle East, Asia and the Pacific (including Sri Lanka, Malaysia, Philippines, Pakistan, Fiji and Samoa) are likely to be erroneous as no voucher material has been provided and all ‘citrus flower moth’ specimens examined from these areas were misidentified (CABI, 2004). The species involved are probably the related *Prays endocarpa* (Indian subcontinent; South-East Asia), *Prays endolemma* (Philippines) and *Prays nepholemina* (Borneo, Australasia). Citrus flower moth had previously been reported in Australia by EPPO but was removed in 2002 following an authoritative check of the genus by Nielsen and Edwards (1996) that found *Prays nepholemina* to be endemic in Australia, with no records of *Prays citri*.

The flower moth in this extension of existing policy is:

- *Prays citri* Millière [Lepidoptera: Yponomeutidae] – citrus flower moth.

Introduction and spread probability

Probability of importation

The likelihood that the citrus flower moth (CFM) will arrive in Australia with the importation of sweet oranges from Italy: **Moderate**.

- CFM has been recorded as being present on citrus in Italy (EPPO, 2002).
- In the Mediterranean region, all stages of the insect may be found throughout the year (Garrido & Ventura, 1993; Mineo *et al*., 1991).
- Eggs are laid individually on the flowers and sometimes on fruit (Mineo *et al*., 1991).
- The young caterpillar enters the flower bud and devours the folded flower parts, then exits by a round lateral hole and enters another bud that it proceeds to empty in the same fashion. It spins silken threads that cover the attacked inflorescences. After the first stage of fruit formation, CFM attacks the young fruit, penetrating it laterally via the receptacle (HYPP, 2004a).
- Cocoons may be found on fruits, flowers and leaves (Mendonca *et al*., 1997).
- On lemons, females lay eggs not only on the flower buds and the developing fruits but also on leaf shoots and larger fruits (Mineo, 1967).
- Fully-grown larvae are 7 mm long and adults are 10 to 12 mm (HYPP, 2004a) and are likely to be detected during pre-export inspections.
- Post-harvest rots can develop on infested fruits and such fruit may be detected during pre-export inspections.
- CFM is likely to survive storage and transportation.
- Routine packinghouse procedures (washing, waxing and grading) may not remove all citrus flower moth from the fruit.

Probability of distribution

The likelihood that the CFM will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- The commodity may be distributed throughout the PRA area for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.

- CFM could enter the environment via adult emergence from pupae in waste that has been discarded before the fruit desiccates or decays.
- If adult moths were to survive cold storage, they could enter the environment by flight from fruit at the point of sale, during transportation of purchased fruits from retailers to households and from discarded fruit waste at landfills.
- The natural dispersal stage for the citrus flower moth is the adult.
- Early instar larvae that have escaped detection during inspection would be unlikely to develop in discarded fruit before the fruit desiccates or decays.
- The larvae would also be unlikely to find a suitable host on which to complete their development.

Probability of entry (importation x distribution)

The likelihood that the CFM would enter Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that CFM 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**.

- All citrus species are hosts of this pest, although it demonstrates a preference for *Citrus limon*, *Citrus aurantifolia*, *Citrus decumana*, and to a lesser extent, *Citrus aurantium*, *Citrus reticulata*, *Citrus sinensis*, *Casimiroa edulis*, *Ligustrum lucidum*, and *Manilkara zapota* (Ibrahim & Shahateh, 1984; Garrido & Ventura, 1993; Sinacori & Mineo, 1997). Many of these species are wide spread in the PRA area.
- The life cycle of CFM can be completed in 20 days, depending on temperature (20 days in summer and 60 days in winter). Females lay 1 to 3 eggs on a flower bud and then move to another.
- Females are reported to be capable of laying 60-165 eggs (Balachowsky, 1966; Garrido & Ventura, 1993; Carvalho & Aguiar, 1997) although in Egypt, females have been reported to lay up to 334 eggs (Ibrahim & Shahateh, 1984).
- The number of generations per year varies from 3-16, depending on climatic conditions. In Sicily and across the Mediterranean region there are 11 generations per year (HYPP, 2004a), in Israel there are between 8 and 10 generations per year (CABI, 2004) and in Egypt 15 generations per year are reported (Ibrahim & Shahateh, 1984).
- CFM is likely to adapt to Australian conditions, given its wide climatic tolerance in the Mediterranean region. The related species *Prays parilis* and *Prays nephelomima* are already established in New South Wales and Queensland (Smith *et al*., 1997a), indicating that CFM may establish in Australia.
- Existing control programs may be effective for some hosts but not all hosts.

Probability of spread

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

- The long distances between the main Australian commercial citrus orchard districts may make it difficult for CFM to disperse directly from one area to another by natural spread.
- Short-distance dispersal occurs as adult moths are mobile and able to rapidly move between host plants.
- Long-distance dispersal occurs as adults are capable of flight. Adults fly at dusk and during the day rest in host trees.
- Environments (e.g. temperature, rainfall) similar to those in Mediterranean region occur in parts of Australia.
- The relevance of natural enemies to the spread of the CFM in Australia is not known.

Probability of entry, of establishment and of spread

The overall likelihood that the CFM will enter Australia as a result of trade in sweet oranges from Italy, 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 probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of the Citrus flower moth: **Moderate**

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — CFM is capable of causing direct damage to a wide range of citrus hosts. It is a serious pest of citrus in the Mediterranean region. Larval feeding has resulted in up to 90% loss in flower production in Spain, and 15-70% flower reduction in Portugal (Mendonca *et al*., 1997). It is also considered an economically important pest in Egypt (Ibrahim & Shahateh, 1984), Israel (Sternlicht *et al*., 1990) and Portugal (Mendonca *et al*., 1997).
Any other aspects of the environment	**A** — CFM introduced into a new environment will compete for resources with native species. This is 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.	**D** — Programs to minimise the impact of this pest on host plants are likely to be costly and include pesticide applications and crop monitoring. A control program would have to be implemented in infested orchards to reduce fruit damage and yield losses, thereby increasing production costs. CFM is a key pest of lemon orchards. The management of CFM is actually dependent on chemical control and up to 12 insecticide treatments per year may be carried out against CFM. Eradication and control costs would be significant at the regional level.
Domestic trade	**C** — The presence of CFM in commercial production areas may have a highly 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	**D** — The presence of these pests in the commercial production areas of a range of commodities may have a significant effect at the regional level due to any limitations to access to overseas markets where this pest is absent. The major risk for Australia arises from the imposition of additional phytosanitary restrictions on exported fruits should CFM become established, even temporarily, in Australia.
Environment	**A** — Pesticides required to control CFM are estimated to have consequences

Criterion	Estimate
	that are unlikely to be discernible at the national level and of minor significance at the local level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for citrus flower moth, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Low**.

4.2.2.1.10 Western flower thrips

Western flower thrips (WFT) is a serious worldwide pest of ornamentals, vegetables, and fruit crops in the field and greenhouse (Ludwig & Oetting, 2001). It is an efficient vector of impatiens necrotic spot and tomato spotted wilt tospoviruses, which cause serious diseases of a wide variety of plants, including vegetable, flower, and ornamental crops (Allen *et al*., 1990; Jones, 1993). There are no records of impatiens necrotic spot tospovirus for Australia but tomato spotted wilt virus is present in Australia (Jones, 1993). Transmission of tospoviruses by thrips is dependent on the development of the thrips on infected plants. WFT is the only thrips species that can transmit impatiens necrotic spot virus (Cloyd & Sadof, 2003).

The thrips examined in this extension of existing policy is:

- *Frankliniella occidentalis* (Pergande) [Thysanoptera: Thripidae] – western flower thrips.

Introduction and spread potential

Probability of importation

The likelihood that western flower thrips (WFT) will arrive in the PRA area with the importation of sweet oranges from Italy**: High**.

- WFT is known to be associated with sweet oranges in Italy (Marullo, 2002).
- The female WFT has an external ovipositor with two opposable serrated blades that are used to cut through the epidermis of plants and deposit eggs in the tissues below (Childers & Achor, 1995).
- The small size of thrips allows them to hide in small crevices and tightly closed plant parts.
- Post-harvest grading and packing procedures are likely to reduce the number of WFT on the fruit.
- WFT can survive packinghouse procedures. AQIS inspectors have intercepted WFT on citrus and other horticultural produces (PDI, 2003).

Probability of distribution

The likelihood that WFT will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Moderate**.

- Adults and immature forms may hide in crevices on the fruit stems and therefore remain with the commodity during distribution via wholesale or retail sale.

- The commodity may be distributed throughout the PRA area for retail sale. The intended use of the commodity is human consumption but waste material would be generated.
- Adults and larvae of WFT can survive sub-zero temperatures and still reproduce effectively (McDonald *et al*., 1997). The eggs are probably susceptible to desiccation and subject to high mortality, but there is also high mortality due to failure of first instar larvae to emerge safely from their egg.
- WFT could enter the environment directly from purchased fruit, from fruit at the point of sale, or through eggs that have hatched in discarded fruit or fruit waste before the fruit desiccates or decays.
- WFT is highly polyphagous and the adults and nymphs can disperse locally by wind-assisted flight (CABI/EPPO, 1997).

Probability of entry (importation x distribution)

The likelihood that WFT will enter the PRA area as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Moderate**.

- The overall probability of entry is determined by combining the probabilities of importation and of distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

Comparative assessment of factors in the source and destination areas considered pertinent to the ability of the pest to survive and propagate: **High**.

- WFT is highly polyphagous (Carnations, *Citrus*, Cucurbitaceae, *Phaseolus* and *Prunus*) and hosts are commonly found in the PRA area.
- Depending on environmental conditions and nutrient levels, female WFT lay 130–230 eggs during their lifetime (CABI, 2004). Eggs are deposited in leaves, bracts, and petals and hatch in 2 to 4 days (Pfleger *et al*., 1995). The development time from egg to adult is 7 to 13 days when temperatures range from 18 to 23^{o}C (CABI, 2004).
- WFT have a high reproductive potential and under glasshouse conditions *Frankliniella occidentalis* can have 15 generations per year (Bryan & Smith, 1956; Lublinkhof & Foster, 1977).
- Many Australian environments are suitable for the survival and reproduction of thrips, as these pests are noted for their ecological and physiological tolerance. WFT is already established in most areas of Australia but is absent from the Northern Territory and under official control in Tasmania.
- Existing control programs may be effective for some hosts (e.g. broad spectrum pesticide applications) but not all hosts (e.g. citrus where specific integrated pest management programs are used). However, WFT has developed resistance to the major classes of insecticides used for its control (Brodsgaard, 1994; Zhao *et al*, 1995).

Probability of spread

Comparative assessment of those factors in the area source and destination areas considered pertinent to the expansion of the geographical distribution of the pest: **High**.

- Natural physical barriers (e.g. deserts/arid areas) may prevent WFT spreading unaided but adults are capable of flight.
- Adults and immature forms may spread by the movement of infested fruit or vegetative host material.

- The international spread of WFT has occurred predominantly by the movement of horticultural material, such as cuttings, seedlings and potted plants.
- WFT has rapid reproductive cycles, and its populations can increase faster than its predators (Mound & Teulon, 1995).
- The relevance of natural enemies in Australia is not known.
- Similar environments (e.g. temperature, rainfall) occur in Italy and Australia.

Probability of entry, of establishment and of spread

The overall likelihood that WFT will enter the PRA area as a result of trade in sweet oranges from Italy, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Australia: **Moderate**.

- The probability of entry, of establishment and of spread is determined by combining the probabilities of entry, establishment and spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consideration of the direct and indirect consequences of WFT: **low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — WFT is probably the most serious pest of floriculture crops in the world (Ludwig & Oetting, 2001). WFT damage plants directly by feeding and laying eggs on the plant, and indirectly by acting as vectors for viruses such as tomato spotted wilt virus and impatiens necrotic spot virus (Cloyd & Sadof, 2003). In some host species, WFT feeding causes flower or leaf buds to abort or emerging leaves to become distorted (Childers & Achor, 1995).
Any other aspects of the environment	**A** — There are no known direct consequences of WFT species on any aspects of the environment but their introduction into a new environment may lead to competition for resources with native species.
Indirect consequences	
Eradication, control, etc.	**B** — The control strategies already in place for thrips in Australia would minimise the impact of the introduction of WFT into new areas of Australia.
Domestic trade	**C** — The introduction of WFT into commercial production areas of Northern Territory and Tasmania may have a significant effect due to any resulting interstate trade restrictions on a wide range of commodities. Interstate measures are currently in place for WFT.
International trade	**C** — The presence of WFT in commercial production areas of a range of commodities (e.g. vegetables, ornamentals and stone fruit) 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 or other control activities would be required to control these pests on susceptible crops but any impact on the environment is likely to be minor at the local level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk for western flower thrips, estimate determined by combining the overall 'probability of entry, establishment or spread' with the 'consequences' using the risk estimation matrix (Table 5)**: Low**.

4.2.2.2 Predatory mites

4.2.2.2.1 Phytoseiid mites

Phytoseiid mites are predators of phytophagous mites and insects and are of ecological and economic significance as biological control agents in most agricultural and natural environments (McMurtry, 1982; Helle & Sabelis, 1985; Kostiainen & Hoy, 1996). Two distinct feeding types of phytoseiid mites have been recognised: the specialised feeders that feed almost exclusively on spider mites and the generalists that feed on spider mites, insects and pollen (Luh & Croft, 2001).

The phytoseiid mites examined in this extension of existing policy are:

- *Amblyseius aberrans* (Oudemans) [Acari: Phytoseiidae] – phytoseiid mite
- *Amblyseius barkeri* (Hughes) [Acari: Phytoseiidae] – phytoseiid mite
- *Amblyseius degenerans* (Berlese) [Acari: Phytoseiidae] – phytoseiid mite
- *Amblyseius italicus* Chant [Acari: Phytoseiidae] – phytoseiid mite
- *Amblyseius potentillae* (Garman) [Acari: Phytoseiidae] – phytoseiid mite
- *Amblyseius stipulatus* Athias-Henriot [Acari: Phytoseiidae] – phytoseiid mite
- *Amblyseius swirskii* Athias-Henriot [Acari: Phytoseiidae] – phytoseiid mite
- *Neoseiulus californicus* McGregor [Acari: Phytoseiidae] – phytoseiid mite
- *Typhlodromus exhilaratus* Ragusa [Acari: Phytoseiidae] – phytoseiid mite
- *Amblydromella rhenanoides* (Athias-Henriot) [Acari: Phytoseiidae] – phytoseiid mite
- *Typhlodromus talbii* Athias-Henriot [Acari: Phytoseiidae] – phytoseiid mite

The phytoseiid mites listed above have been recorded in citrus orchards in Italy. Due to the recognised importance of *Neoseiulus californicus* in integrated pest management systems, it was used as the basis for the risk assessment.

Introduction and spread probability

Probability of importation

The likelihood that phytoseiid mites will arrive in Australia with the importation of sweet oranges from Italy: **High**.

- These phytoseiid mites are reported from citrus production areas in Italy (Vacante & Nucifora, 1986; Vacante *et al*., 1988).
- *Neoseiulus californicus* lay eggs along the midvein of the leaves (Malais & Ravensberg, 2003).
- *Neoseiulus californicus* is a highly mobile, generalist predator. Adults and immatures will search all parts of the plant for prey (Weeden *et al*., 2005) or alternative food, for example pollen, and are strongly attracted to chemicals given off either by plants damaged by the prey species or by the prey species itself (Gilstrap & Friese, 1985).
- *Neoseiulus californicus* shows a feeding preference for the larval and nymphal stages of the two-spotted spider mite when the pest is present at low densities (Malais & Ravensberg, 2003).
- Plants infested by phytophagous mites emit volatile organic compounds, and predatory mites use these volatiles as cues to find their prey (Dicke *et al*., 1986; Llusia & Penuelas, 2001).
- Phytophagous mites also directly emit volatile organic compounds that can elicit searching behaviour in phytoseiid mites (Dicke *et al,* 1986).

- Phytoseiid mites can survive packinghouse procedures. AQIS inspectors have intercepted phytoseiid mites on various horticultural produce (PDI, 2003).

Probability of distribution

The likelihood that phytoseiid mites will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- Adults or nymphs may remain on the surface of the fruit during distribution via wholesale or retail trade.
- Distribution of the commodity in the PRA area could be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Extended cold storage can reduce the survivorship of phytoseiid mites (Gillespie & Ramey, 1988).
- Phytoseiid mites subjected to any environmental change need some time to adapt to new conditions (Castagnoli *et al*., 2001).
- The generalist diet would increase survival chances. *Neoseiulus californicus* can survive for a few days by feeding solely on a diet of pollen (Malais & Ravensberg, 2003).
- Predatory mites are known to use volatiles emitted from plants infested with phytophagous arthropods to locate their prey/host (Dicke, 1994; Takabayashi & Dicke, 1996; Vet & Dicke, 1992).
- *Neoseiulus californicus* is capable of aerial dispersal (Johnson & Croft, 1981; McMurtry & Croft, 1997; Tixier *et al*., 1998). The population on the discarded fruit may decline quickly as a result of desiccation; eggs are particularly sensitive to desiccation (Karban *et al*., 1995).

Probability of entry (importation x distribution)

The likelihood that phytoseiid mites will enter Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that phytoseiid mites 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**.

- *Neoseiulus californicus* is associated with several agricultural crops including strawberries, raspberries, roses, grapes, citrus, ornamentals and vegetables (Johnson & Lynon, 1991; Hoddle, 2000; Liburd *et al*., 2003; Rondon *et al*., 2004). These hosts are widespread in the PRA area.
- *Neoseiulus californicus* feeds on important fruit pests and ornamental pests such as *Tetranychus urticae*, *Polyphagotarsonemus latus*, *Tarsonemus pallidus* and other mite species (Hoddle, 2000). Some of these mite species are widespread in the PRA area.
- *Neoseiulus californicus* is an opportunist predator and is capable of feeding on several different types of prey including thrips (Sabelis & Van Rijn, 1997), other phytoseiid mites (Walzer & Schausberger, 1999) in addition to tetranychid prey, indicating that they have high survival rates at low prey densities (McMurtry, 1982).

- *Neoseiulus californicus* is found in warm humid areas of the Americas, Europe and Mediterranean climates (Malais & Ravensberg, 2003). Similar environments occur in the PRA area that would be suitable for establishment of this mite.
- In phytoseiid mites, prey consumption affects egg production, which reaches its maximum early in the oviposition period (Abou-Setta & Childers, 1991; Sabelis & Janssen, 1993).
- Mated females overwinter in bark crevices and under insect scales and lay 40-60 eggs (McMurtry & Croft, 1997).
- *Neoseiulus californicus* has a short generation time. The life cycle of the mite takes between 3-4 weeks, depending on temperature (McMurtry & Croft, 1997).
- Persistence after prey extinction is related to a predator's capacity to survive on alternative food sources and to out-compete other predatory species, frequently of closely related taxa (Duso & Vettorazzo, 1999).
- Some populations of phytoseiid mites are resistant to organophosphates (Hoyt, 1969; Croft & Barnes, 1971) and pyrethroid insecticides (Alvella *et al*., 1985; Solomon *et al*., 2000).

Probability of spread

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

- Movement of commodities would help the dispersal of phytoseiid mites because these mites could be on the fruit. Adults and juvenile stages may be spread on contaminated plant material.
- Phytoseiid mites disperse mostly by crawling and aerial spread (Croft & Jung, 2001; Johnson & Croft, 1981; McMurtry & Croft, 1997; Tixier *et al*., 1998). Dispersal by crawling in a local patch when food, shelter and oviposition or wintering sites are sought. Aerial dispersal often results in the movement of mites to a new site and spread of a population over a crop (Croft & Jung, 2001).
- In aerial dispersal, phytoseiid mites move to the edge of the leaf and then orientate to the air flow (Johnson & Croft, 1976). Both wind speed and direction have an impact on dispersal (Tixier *et al*., 1998).
- Starved adult females of phytoseiid mites display explicit aerial dispersal behaviour in low to moderate wind speeds. Well-fed mites do not show aerial dispersal behaviour, indicating food availability is a component stimulating aerial dispersal (Hoy *et al*., 1985).
- A predator needs to locate prey populations once aerial dispersal has occurred. Kairomones produced by spider mites as well as predator-emitted marking pheromones (Hislop & Prokopy, 1981) assist predators in locating or staying in populations of prey (Zhang & Sanderson, 1997). Such activities help phytoseiid mites spread into new environments.
- Phytoseiid mites are active and fast moving (Muma & Selhime, 1971) and move continuously while foraging for prey or other food (Sabelis, 1985). Their foraging behaviour may not only depend upon prey availability but also on abiotic factors such as relative humidity, temperature and light intensity (Villanueva & Childers, 2005).
- Several carnivorous species (*Phytoseiulus persimilis*, *Typhlodromalus manihotis*, *Typhlodromalus aripo* and *Scolothrips takahashii*) have been reported to respond to

volatile compounds produced by leaves infested with phytophagous mites (Dicke *et al*., 1990; Gnanvossou *et al*., 2002; Shimoda *et al*., 1997).

Probability of entry, of establishment and of spread

The overall likelihood that phytoseiid mites will enter Australia as a result of trade in sweet oranges from Italy, be distributed in a viable state to suitable hosts, establish in the area and subsequently spread within Australia: **Low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of phytoseiid mites: **Moderate**.

Criterion	Estimate
Direct consequences	
Plant life or health	**A** — There is no evidence that phytoseiid mites feed on plants even under instances of extreme starvation although *Neoseiulus* species can live and reproduce using pollen as their food source (Pratt *et al*., 1999).
Any other aspects of the environment	**D** — Predacious mites interact inter-specifically through competition for prey or feeding on each other (Croft & MacRae, 1993). Mutual predation reported among predatory mites could result in localised displacement of established mites in the natural ecosystem (Reitz & Trumble, 2002).
Indirect consequences	
Eradication, control etc.	**C** — Additional programs to minimise the impact of phytoseiid mites would be necessary. Some populations of phytoseiid mites are resistant to organophosphate (Hoyt, 1969; Croft & Barnes, 1971) and pyrethroid insecticides (Alvella *et al*., 1985; Solomon *et al*., 2000).
Domestic trade	**A** — The presence of phytoseiid mites in the PRA area is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.
International trade	**A** — The presence of phytoseiid mites in the PRA area would not have a significant effect, as phytoseiid mites are widely used as biocontrol agents in various countries.
Environment	**D** — Phytoseiid mites may have some effect on arthropod fauna at the national level. Generalist predators may compete for prey with local fauna and have the potential to feed on all available suitable hosts (Howarth, 1991).

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for phytoseiid mites, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Low**.

4.2.2.2.2 Stigmaeid mites

Stigmaeid mites are predators of phytophagous mites and feed on a variety of prey, including European red mite, two-spotted spider mite, rust mites, tydeid mites and scales (Weeden *et al*., 2005). Some species within the genera *Agistemus* and *Zetzellia* are important biological control agents. Stigmaeid mites also feed on pollen when prey population levels are low (Weeden *et al*., 2005).

The stigmaeid mites examined in this extension of existing policy are:

- *Eryngiopus bifidus* Wood [Acari: Stigmaeidae] – stigmaeid mite
- *Eryngiopus siculus* Vacante & Gerson [Acari: Stigmaeidae] – stigmaeid mite
- *Zetzellia collyerae* (Gonzalez-Rodriguez) [Acari: Stigmaeidae] – stigmaeid mite
- *Zetzellia graeciana* Gonzales [Acari: Stigmaeidae] – stigmaeid mite
- *Zetzellia mali* (Ewing) [Acari: Stigmaeidae] – stigmaeid mite

The stigmaeid mites listed above have been recorded in citrus orchards in Italy. Due to the recognised importance of *Zetzellia mali* in integrated pest management programs, it was used as the basis for the risk assessment.

Introduction and spread probability

Probability of importation

The likelihood that stigmaeid mites will arrive in Australia with the importation of sweet oranges from Italy: **High**.

- These stigmaeid mites are reported from citrus production areas in Italy (Vacante & Nucifora, 1986; Vacante & Gerson, 1987).
- *Zetzellia mali* is the most important non-phytoseiid mite predator of phytophagous mites, including tetranychid and eriophyid mites (Woolhouse & Harmsen, 1984; Solomon *et al*, 2000) and is used in integrated pest management programs.
- Phytophagous mites can be associated with fruit and since *Z. mali* follows its prey, it may also be associated with fruit.
- *Zetzellia mali* feeds on eggs and immature stages of tetranychid and eriophyid mites (Santos & Laing, 1985; Clements & Harmsen, 1992), in contrast to phytoseiid mites which prefer mobile stages.
- *Zetzellia mali* is less active than phytoseiid mites and is slower than phytoseiid mites to increase in population size (Weeden *et al*., 2005). However, it has the ability to persist utilising various food sources and has the potential to reach high numbers (Weeden *et al*., 2005).
- Stigmaeid mites can survive packinghouse procedures. AQIS inspectors have intercepted stigmaeid mites on citrus (PDI, 2003).

Probability of distribution

The likelihood that stigmaeid mites will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- Adults or nymphs may remain on the surface of the fruit during distribution via wholesale or retail trade.
- Distribution of the commodity in Australia could be for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- Extended cold storage can reduce the survivorship of stigmaeid mites (Croft & MacRae, 1993).
- *Zetzellia mali* can survive on several alternative foods when its preferred prey is absent (Weeden *et al*., 2005). In the absence of suitable prey, *Z. mali* can survive for a few days feeding solely on a diet of pollen (White & Laing, 1977a) or phytoseiid mite eggs (Santos, 1976) and may cannibalise its own eggs (Clements & Harmsen, 1992).

Probability of entry (importation x distribution)

The likelihood that stigmaeid mites will enter Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that stigmaeid mites 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**.

- *Zetzellia mali* is associated with several agricultural cropping systems including apples (Croft & MacRae, 1993). These hosts are wide spread in Australia.
- *Zetzellia mali* feeds on important fruit and ornamental pests such as *Panonychus ulmi*, *Tetranychus urticae*, *Aculus schlechtendali* (Croft *et al*., 1992) and *Brevipalpus phoenicis* and *Phyllocoptruta oleivora* (Sato *et al*., 2001). Some of these preferred host species are widespread in Australia.
- *Zetzellia mali* is capable of feeding on several different types of prey including eggs and immature stages of tetranychid mites and eriophyid mites (Woolhouse & Harmsen, 1984; Santos & Laing, 1985), pollen, sap and fungal spores indicating that they have high survival rates at low prey densities (Clements & Harmsen, 1990).
- *Zetzellia mali* lays eggs along the midvein on the lower surface of the leaf (Weeden *et al*., 2005). Mated females overwinter in bark crevices and under scales of insects (White & Laing, 1977b).
- *Zetzellia mali* has a short generation time. Three to four generations per year have been reported (Solomon *et al*., 2000) and stigmaeid mites population cycles are linked with those of their prey (Solomon *et al*., 2000).
- When the favoured prey is scarce, some species may survive by seeking alternative foods or by predation on their own or other phytoseiid species (McMurtry & Croft; 1997).

Probability of spread

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

- Movement of commodities would help the dispersal of stigmaeid mites because phytophagous mites could potentially be on the fruit.
- *Zetzellia mali* feeds on eggs and immature stages of tetranychids and eriophyids (Santos & Laing, 1985). This prey preference reflects its low mobility and low dispersion capacity when compared to phytoseiid mites.
- Physical barriers may prevent long-range spread of stigmaeid mites. Under field conditions, *Z. mali* is slow to explore the tree in search of new prey, so as pest mites (such as European red mite) move from older leaves to new feeding sites, they can escape predation by this mite (Weeden *et al*., 2005).
- However, if stigmaeid mites were to be introduced to the production areas, physical barriers are unlikely to be a limiting factor for the spread of these mites within the orchard.

Probability of entry, of establishment and of spread

The overall likelihood that stigmaeid mites will enter Australia as a result of trade in sweet oranges from Italy, be distributed in a viable state to suitable hosts, establish in the area and subsequently spread within Australia: **Low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of the stigmaeid mites: **Moderate**.

Criterion	Estimate
Direct consequences	
Plant life or health	**A**— There is no evidence of phytophagy even under instances of extreme starvation although the species has been found to feed and reproduce on pollen, sap and fungal spores (White & Laing, 1977a).
Any other aspects of the environment	**D**— Predacious mites interact inter-specifically through competition for prey or feeding on each other (Croft & MacRae, 1993). Mutual predation reported among predatory mites could result in localised displacement of established mites in the natural ecosystem (Reitz & Trumble, 2002). *Zetzellia mali* is known to displace other mites including *Metaseiulus occidentalis* and *Typhlodromus pyri* (Croft & MacRae, 1993).
Indirect consequences	
Eradication, control etc.	**C** — Additional programs to minimise the impact of stigmaeid mites would be necessary. Some populations of stigmaeid mites are resistant to organophosphate insecticides (Croft, 1994).
Domestic trade	**A** — The presence of stigmaeid mites in the PRA area is estimated to have consequences that are unlikely to be discernible at the regional level and of minor significance at the local level.
International trade	**A** — The presence of stigmaeid mites in the PRA area would not have a significant effect, as stigmaeid mites are widely used as biocontrol agents in various countries.
Environment	**D** — *Zetzellia mali* does have a negative impact on phytoseiid mite populations and this impact is greater on some species of phytoseiids than others (Croft & MacRae, 1993). Additionally it may have some effect on arthropod fauna at the national level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for stigmaeid mites, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Low**.

4.2.2.3 Pathogens

4.2.2.3.1 Brown rot

Phytophthora spp. cause the most serious and economically important soil-borne diseases of citrus (Graham & Timmer, 2003). The most widespread and important *Phytophthora* spp. that attack citrus are *P. nicotianae* and *P. citrophthora*. These species are worldwide in distribution and cause citrus production losses in irrigated, arid areas as well as in areas with high rainfall. Diseases of citrus caused by *Phytophthora* spp. include damping-off, foot rot, gummosis, root rot and brown rot of fruit (Zitko *et al*., 1991). *Phytophthora palmivora* is a common cause of brown rot epidemics in Florida and probably causes brown rot and foliage blights in other humid subtropical and tropical areas of the world (Timmer *et al*., 2000). *Phytophthora syringae* causes brown rot to a limited extent in areas with cool, wet winters (Timmer *et al*., 2000). Brown rot epidemics are usually restricted to areas where rainfall coincides with the early stages of fruit maturity (Graham & Timmer, 2003).

The pathogens examined in this extension of existing policy are:

- **Phytophthora palmivora* (E.J. Butler) E.J Butler – brown rot
- **Phytophthora syringae* (Kleb.) Kleb. – brown rot

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

Introduction and spread probability

Probability of importation

The likelihood that *P. palmivora* and *P. syringae* will arrive in Western Australia with the importation of sweet oranges from Italy: **Low**.

- These pathogens are associated with citrus in Italy (AAN, 1998).
- When conditions are favourable, fruit approaching maturity is infected by sporangia and zoospores splashed from the soil or by inoculum from aboveground parts of the plant that is dispersed by rain splash or wind blown rain. (Graham & Timmer, 2003).
- Epidemics of brown rot caused by *P. palmivora* are prevalent during prolonged rains in late summer and autumn and those caused by *P. syringae* during midwinter (Timmer *et al*., 2000).
- Most infected fruits abscise but those that are harvested may not show symptoms until after they are held in storage for a few days (Graham & Timmer, 2003).
- Fruit that become infected shortly before harvest may not show symptoms and might be overlooked and be exported (Timmer *et al*., 2000; Brown, 2003). However, they will show symptoms in cold storage after a few days (Graham & Timmer, 2003).
- Infected fruit shows light brown discoloration of the rind at any location on the fruit surface. White mycelium forms on the rind surface under humid conditions (Timmer *et al*., 2000).
- Infected fruit has a characteristic pungent, rancid odour, which distinguishes this disease from stem-end rot (Timmer *et al*., 2000).
- Fruit with symptoms of brown rot (Timmer *et al*., 2000) would be rejected during routine harvesting and grading operations.

Probability of distribution

The likelihood that *P. palmivora* and *P. syringae* will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- If sweet oranges were imported, they would be distributed in Western Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.

- *Phytophthora palmivora* and *P. syringae* are likely to survive cold storage and transportation (Brown, 2003).
- On infected fruit, sporangia can be produced from mycelium. Sporangia are only produced under specific conditions of humidity (long period of wetting – 18 hours or more) and temperature (23-28°C) (Timmer *et al*., 2000; Graham & Timmer, 2003).
- The production of sporangia depends directly on calcium concentration, the presence of sterols, aeration, light and temperature (Erwin & Ribeiro, 1996).
- Sporangia can persist for several hours at moderate humidity while attached to sporangiophores and are shed in saturated air. *Phytophthora palmivora* is probably capable of forming sporangia over most of the range of soil moisture conditions (Erwin & Ribeiro, 1996).
- Infected fruit is likely to be discarded and these pathogens may survive and move into the soil, where they could survive as chlamydospores, oospores (when produced) or dormant mycelium in the soil and in plant debris (Brassier & Griffin, 1979).
- Discarded fruit waste containing these pathogens would be rapidly colonised by other saprophytic (feeding by external digestion of dead organic matter) microorganisms.
- *Phytophthora* spp. are parasitic but are poor competitive saprophytes in soil (Graham & Timmer, 2003).
- Chlamydospores may form when soil moisture is limiting, conditions are cool or where the host roots are not actively growing and producing susceptible tissues for infection. Chlamydospores can survive several months under unfavourable conditions (Graham & Timmer, 2003).

Probability of entry (importation x distribution)

The likelihood that *P. palmivora* and *P. syringae* will enter Western Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Very low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that *P. palmivora* and *P. syringae* 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**.

- *Phytophthora palmivora* and *P. syringae* have a wide range of natural hosts (Ploetz *et al*., 2003).
- Natural hosts, including citrus, are widely distributed throughout Western Australia, both in commercial orchard districts and suburban areas.
- Spores encyst in free water on fruit surfaces, germinate and the hyphae penetrate the intact rind in a few hours. Lesions become visible within 3 to 4 days at ambient temperatures (Brown, 2003).
- *Phytophthora palmivora* and *P. syringae* are already established in parts of Australia, indicating that suitable environments for their establishment would occur in Western Australia.
- The temperature range for infection is 23-28°C. Optimum temperatures for mycelial growth range from 22-30°C and chlamydospores become dormant below 15°C (Graham & Timmer, 2003).

- *Phytophthora* spp. infect fruit in contact with the ground or by sporangia or zoospores dispersed by rain splash or wind blown rain (Graham & Timmer, 2003). Additional spores may be produced on infected fruits and disseminated by water to fruit higher in the tree (Brown, 2003). *Phytophthora palmivora* produces air-borne sporangia that can infect fruit throughout the canopy (Graham & Timmer, 2003).
- Sporangia are only produced under specific conditions of humidity (long period of wetting – 18 hours plus) and temperature (22-28°C) (Timmer *et al*., 2000; Graham & Timmer, 2003). Conditions favouring development of the disease are temperatures of 20-28°C, precipitation above 40 mm per day (100 mm during 2-3 days), and fruits at the most susceptible stage (change of colour) (EPPO, 2004).
- Inoculum levels increase rapidly due to very short time required for the production of sporangia and zoospores (Graham & Timmer, 2003).
- *Phytophthora palmivora* survives dry periods as dormant chlamydospores, oospores (when produced) or dormant mycelium in the soil and in plant debris (Brassier & Griffin, 1979). All of these survival structures can produce sporangia and zoospores when it rains. Chlamydospores are the most important of these survival structures (Brassier & Griffin, 1979).

Probability of spread

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

- *Phytophthora palmivora* and *P. syringae* spread in Mediterranean and tropical climates (Waterhouse & Waterston, 1964; Timmer *et al*., 2000) and environments similar to these areas exist in various parts of Western Australia.
- Natural hosts, including citrus species, are widely distributed throughout Western Australia, both in commercial orchard districts and suburban areas.
- The long distances between the main citrus production districts in Western Australia would make it difficult for these fungi to move directly from one district to another by natural spread.
- The primary means by which *Phytophthora* spp. are spread to new areas is by movement of infested nursery stock (Graham & Timmer, 2003).
- *Phytophthora* spp. may be present in soil or infected roots even though disease symptoms are not readily apparent in the plant (Graham & Timmer, 2003).
- *Phytophthora* spp. are also carried in soil on equipment when vehicles move from infested to non-infested orchards or nurseries. However, propagule densities decline sharply when soil is air-dried, reducing the probability of spread (Graham & Timmer, 2003).
- Irrigation water may also move the pathogen from area to area, especially where furrow or flood irrigation is used.
- Sporangia are produced by mycelia present on infected fruit under favourable conditions and are then splashed higher into the canopy (Timmer *et al*., 2000).
- Dispersal of sporangia and zoospores in windblown rain permits spread to, and development of, epidemics in plantations and orchards under optimal conditions once the disease is established (Graham & Timmer, 2003).
- *Phytophthora* spp. are parasites but are poor competitive saprophytes in soil (Graham & Timmer, 2003). The pathogen grows well on nutrients obtained from the living plant

and under favourable conditions, undergoes repeated cycles of mycelium to sporangia, zoospores and more mycelium.

- Because of the requirement of water for dispersal and pathogenesis, diseases of aerial parts are worse in areas of high rainfall and high humidity, where shade trees or dense plantings slow the drying of plant surfaces (Thévenin, 1994).

Probability of entry, establishment or spread

The overall likelihood that *P. palmivora* and *P. syringae* will enter Western Australia as a result of trade in sweet oranges from Italy, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Very low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of *P. palmivora* and *P. syringae*: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — While *P. palmivora* and *P. syringae* cause brown rot of citrus fruit, *P. citrophthora*, which occurs in Western Australia, is the most common cause of brown rot in Mediterranean climates (Timmer *et al*., 2000). *Phytophthora palmivora* has a wide host range and can cause significant losses at the district level in crops such as betelnut, papaw, coconut, rubber and cacao. *Phytophthora syringae* has a more restricted host range than *P. palmivora* but can infect some citrus, pome fruit and stone fruit species.
Any other aspects of the environment	**A** — There are no known direct consequences of *P. palmivora* and *P. syringae* on the natural or built environment but their introduction into a new environment may lead to competition for resources with other species.
Indirect consequences	
Eradication, control, etc.	**A** — Programs to minimise the impact of *P. palmivora* and *P. syringae* on host plants are not likely to be more costly than existing management programs for other *Phytophthora* spp.
Domestic trade	**A** — The presence of *P. palmivora* and *P. syringae* in commercial production areas will have a minor effect at the local level due to any resulting interstate trade restrictions as these pathogens are already present in subtropical and tropical parts of eastern Australia.
International trade	**A** — The presence of these fungi in commercial citrus production areas will have a minor effect at the local level due to any limitations to access to overseas markets where these pathogens are absent.
Environment	**A** — Although additional post-harvest fungicide applications might be required to control this disease on citrus, this is unlikely to affect the environment.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for *P. palmivora* and *P. syringae*, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Negligible**.

4.2.2.3.2 Dry fruit rot

Dry fruit rot of oranges, grapefruits and tangerines was first observed in California, USA in the 1920s (Fawcett, 1929). This disease is not mentioned in more recent literature on citrus diseases (Reuther *et al*., 1978; Timmer *et al*., 2000). Recently, the disease has been reported from several locations in eastern Australia (Shivas *et al*., 2005).

The pathogen examined in this extension of existing policy is:

- **Nematospora coryli* Peglion – dry fruit rot.

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

Introduction and spread probability

Probability of importation

The likelihood that *N. coryli* will arrive in Western Australia with the importation of sweet oranges from Italy: **Low**.

- *Nematospora coryli* is associated with citrus in Italy (EPPO, 2004).
- Symptoms of dry fruit rot include dry flesh and brownish discoloured, shrivelled seeds (Shivas *et al*., 2005).
- Infected fruit exhibiting symptoms of dry fruit rot (Shivas *et al*., 2005) would be rejected during harvesting and routine grading operations.
- Post-harvest grading, washing and packing procedures are likely to significantly reduce the number of spores of *N. coryli* on the surface of healthy fruit.

Probability of distribution

The likelihood that *N. coryli* will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- If sweet oranges were imported, they would be distributed in Western Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- It is unlikely the fungus would survive for long periods in discarded waste, as infected fruit would rot quickly in dumpsites, landfills and compost heaps due to the activity of saprophytic organisms.
- *Nematospora coryli* is seed-borne in mandarin, lemon and native lime (Shivas *et al*., 2005) but there is no published report of seed to seedling transmission.

Probability of entry (importation x distribution)

The likelihood that *N. coryli* will enter Western Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Very low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that *N. coryli* 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**.

- *Nematospora coryli* has a wide host range including: *Anacardium occidentale*; *Cajanus cajan*; *Citrus* spp.; *Coffea* spp.; *Corylus avallana*; *Crotalaria* spp.; *Dolichos*

lablab; *Glycine max*; *Gossypium hirsutum*; *Lycopersicon esculentum*; *Phaseolus* spp.; *Pistacia vera*; *Macadamia integrifolia*; *Tephrosia vogelii*; and *Vigna sinensis* (Mukerji, 1968; CABI, 2004; Shivas *et al*., 2005).
- Natural hosts, including highly susceptible *Citrus* species, are widely distributed in Western Australia, both in commercial orchard districts and suburban areas.
- *Nematospora coryli* is established in Australia (New South Wales, Queensland), Africa, Asia, Europe and North and South America (Mukerji, 1968). Environments similar to these areas exist in various parts of Western Australia.
- There is evidence that *N. coryli* has been established in Queensland for at least 90 years (Shivas *et al*., 2005).

Probability of spread

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

- *Nematospora coryli* spreads in tropical and subtropical climates (Mukerji, 1968), and environments similar to these areas exist in various parts of Western Australia.
- Natural hosts, including highly susceptible *Citrus* species, are widely distributed in Western Australia, both in commercial orchard districts and suburban areas.
- The distances between host crops in production districts in Western Australia may limit the natural spread of this fungus from one district to another.
- The detection of this fungus in native lime (*Citrus australis*) poses intriguing prospect that this fungus is native to Australia and has moved from that host onto cultivated citrus (Shivas *et al*., 2005).
- The fungus is usually disseminated by green stink bug (*Acrosternum hilare*), spined citrus bug (*Biprorulus bibax*), stink bugs (*Euschistus euschistoides*, *E. servus*, *E. tristigmus*, *E. variolarius*), red-shouldered stink bug (*Thyanta custator*) (Mukerji, 1968; Shivas *et al*., 2005) and western leaf-footed bug (*Leptoglossus zonatus*) (Johnson, 2004).
- Its dissemination is favoured by bright sunny days which facilitate the movement of the vector from one plant to another (Mukerji, 1968).

Probability of entry, establishment or spread

The overall likelihood that *N. coryli* will enter Western Australia as a result of trade in sweet oranges from Italy, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Very low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of the *N. coryli*: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — Although *N. coryli* was reported to cause serious disease on a range of species and varieties of citrus (Fawcett, 1936), recent literature fails to report it as a pathogen of citrus (Shivas *et al*., 2005). *Nematospora coryli* is a serious pathogen of seeds of many species of tropical and subtropical plants (Shivas *et*

Criterion	Estimate
	al., 2005).
Any other aspects of the environment	**A** — There are no known direct consequences of these pathogens on the natural or built environment.
Indirect consequences	
Eradication, control, etc.	**A** — Programs to minimise the impact of this disease on host plants are not likely to be more costly than existing control programs except in chemical free produce.
Domestic trade	**A** — The presence of this disease in commercial production areas will have a minor effect at the local level due to any resulting interstate trade restrictions on citrus as the pathogen is already present in parts of eastern Australia.
International trade	**A** — The presence of this disease in commercial production areas of citrus will have a minor effect at the local level due to any limitations to access to overseas markets where this pathogen is absent.
Environment	**A** — Additional fungicide applications might be required to control this disease on citrus; this is unlikely to affect the environment.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for *N. coryli* determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Negligible**.

4.2.2.3.3 Mal Secco

Mal secco is a serious fungal disease of citrus, particularly lemons, in the Mediterranean Basin (Tuttobene, 1993). Mal secco also affects *Fortunella*, *Poncirus* and *Severinia* species. Infection of grapefruit and sweet orange is rare and usually not severe (Solel & Salerno, 2000). Mal secco is a tracheomycotic disease causing wilting and dieback of citrus trees (Tuttobene, 1993). It causes a characteristic leaf veinal chlorosis, followed by shedding of the leaves and eventual dieback of the twigs and branches. Following the death of the woody tissue, the causal fungus invades the bark and forms pycnidia under the epidermis. Conidia are dispersed from the pycnidia for limited distances by raindrops and wind-blown rain (Solel & Salerno, 2000). Host resistance, in conjunction with cultural practices (removal and burning of infected twigs and branches and spraying with fungicides), is the most effective means of control (Palm, 1987).

The pathogen examined in this extension of existing policy is:

- *Phoma tracheiphila* (Petri) L.A. Kantachveli & Gikachvili – mal secco.

Introduction and spread probability

Probability of importation

The likelihood that *Phoma tracheiphila* will arrive in the PRA area with the importation of sweet oranges from Italy: **Low**.

- *Phoma tracheiphila* has been reported on lemon, sour orange, citron, bergamot and chinotto orange (*Citrus myrtifolia*) in Italy (AAN, 1998).
- Infection of trees of cultivars of sweet orange (*Citrus sinensis*) is rare and usually not severe (Solel & Salerno, 2000).

- The fungus has affected normally tolerant cultivars of sweet oranges under favourable conditions in Israel (Solel & Oren, 1975).
- In lemon, fruit infection occurs when the pathogen moves from infected branches into fruit (Ippolito *et al*., 1987).
- Infected lemon fruit normally withers and falls to the ground. However, when infected branches desiccate rapidly the fruit remain attached, eventually mummifying on the tree (Ippolito *et al*., 1987).
- When unripe lemon fruit is infected, it shows partial or total yellowing of the peel, depending on the age of the infection. When ripe lemon fruit is infected, it turns dark yellow, almost reddish, in colour (Ippolito *et al*., 1987).
- There are no published records of fruit infection of sweet orange. If fruit infection were to occur in sweet orange, it is likely that it would be detected during pre-export inspections.
- Inoculum of *Phoma tracheiphila* is dispersed for short distances by wind and rain (Laviola & Scarito, 1989), so if infected trees of lemon or other susceptible species were present in an orchard, conidia carried in windblown rain could contaminate the surface of sweet orange fruit.
- Sweet orange fruit is harvested in winter in Italy, when the greatest number of propagules of the pathogen is present (Tuttobene, 1994).
- Post-harvest grading, washing and packing procedures are likely to remove conidia of this fungus from the fruit surface.

Probability of distribution

The likelihood that *Phoma tracheiphila* will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- If sweet oranges were imported, they would be distributed in Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- It is unlikely the fungus would survive for long periods in discarded waste, as infected fruit would rot quickly in dumpsites, landfills and compost heaps due to the activity of saprophytic organisms.
- On infected lemon fruit, conidia can be produced from both pycnidia and phialides produced on mycelium. Free phialides are only produced under specific conditions of humidity and temperature (Ippolito *et al*., 1987).
- Temperatures above 30°C stop mycelial growth but do not kill the fungus within infected host tissues (EPPO, 2004).
- The distance conidia could spread from citrus waste material by water splash is limited (Tuttobene, 1994), but natural hosts, including highly susceptible citrus species, are widely distributed throughout Australia, both in commercial orchard districts and suburban areas.
- *Phoma tracheiphila* is seed-borne in lemon (Stepanov & Shaluishkina, 1952).
- *Phoma tracheiphila* survives in lemon seed as mycelium but is unable to pass from the seed coat to developing seedlings (Ippolito *et al*., 1987).

Probability of entry (importation x distribution)

The likelihood that *Phoma tracheiphila* will enter the PRA area as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Very low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of ‘rules’ for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that *Phoma tracheiphila* 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**.

- *Phoma tracheiphila* has a wide range of natural hosts in the family Rutaceae including *Citrus* spp., *Poncirus trifoliata*, *Fortunella* spp. and *Severinia buxifolia* (Palm, 1987).
- Lemon (*Citrus limon*), citron (*Citrus medica*) and mandarin (*Citrus reticulata*) and some of its hybrids are highly susceptible to the disease (Punithalingam & Holliday, 1973). Lime (*Citrus aurantifolia*) has been severely affected in Israel (Palm, 1987).
- Native *Citrus* species are widespread in Australia but their susceptibility to mal secco is not known.
- Natural hosts, including highly susceptible introduced citrus species, are widely distributed throughout Australia, both in commercial orchard districts and suburban areas.
- *Phoma tracheiphila* is established in the Mediterranean basin, around the Black Sea and in Asia Minor (Solel & Salerno, 2000). Environments similar to these areas exist in parts of Australia.
- The temperature range at which infection occurs is considered to be between 14 and 28°C. The optimum temperature for growth of the pathogen, and for symptom expression, is 20-25°C, whereas the maximum temperature for mycelial growth is 30°C (Smith *et al.*, 1997b).
- Infection and transmission occur from November to February in Sicily and mid-November to mid-April in Israel, coinciding with the rainy season (Palm, 1987).
- In the Mediterranean region, infection periods depend on local climatic and seasonal conditions. In Sicily, infections usually occur between September and April (Smith *et al.*, 1997b).
- The fungus enters the plant mainly through injuries to the leaves, branches, trunk and roots. Entry through stomata has not been proven (Palm, 1987).
- Injuries to trees caused by wind, frost and hail provide sites for initial infections (Perrotta & Graniti, 1988). Destructive outbreaks may occur after frost spells and hail storms in spring (Perrotta & Graniti, 1988).
- Young tissue is particularly susceptible to infection (Perrotta & Graniti, 1988).
- New infections are initiated by water-borne conidia (Solel, 1976).
- When infection starts in the canopy, it may take several years for the disease to move downward and involve the trunk. However, when the disease originates as a basal or root infection, tree collapse can be rapid.
- Development of races of *Phoma tracheiphila* has been postulated but specialisation in the fungus has not been reported (Palm, 1987).

- A combination of cultural practices, use of resistant cultivars and to a lesser extent chemical control treatments is used to manage and control this fungus (Palm, 1987).

Probability of spread

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

- *Phoma tracheiphila* has spread in the Mediterranean basin, around the Black Sea and in Asia Minor (Solel & Salerno, 2000), and environments similar to these areas exist in various parts of Australia.
- Natural hosts, including highly susceptible introduced citrus species, are widely distributed throughout Australia, both in commercial orchard districts and suburban areas.
- The long distances between the main citrus production districts in Australia would make it difficult for this fungus to move directly from one district to another by natural spread.
- Conidia are produced by pycnidia present on infected host tissue (Punithalingam & Holliday, 1973), including branches, leaves and to a lesser extent, fruit on the ground (Holliday, 1980). Inoculum is usually provided by conidia extruded from pycnidia on withered twigs and suckers (EPPO, 2004).
- Conidia produced on the surface of wounds following pruning of infected twigs or branches can provide a source of inoculum for several weeks (Perrotta & Graniti, 1988).
- Conidia are also produced from phialides borne on free hyphae on exposed woody surfaces of the tree or on debris (Solel, 1976).
- Lemon fruit (Ippolito *et al*., 1987) and above ground shoots/branches/trunks (Palm, 1987) are known to carry spores and hyphae of the pathogen, which can be internally or externally borne.
- The fungus can survive within infected twigs in the soil for more than 4 months (Ippolito *et al*., 1987).
- Reports indicate that the disease spreads rapidly during autumn, winter and early spring but spread in the host ceases at high summer temperatures (Punithalingam & Holliday, 1973).
- Infection and transmission occur from November to February in Sicily and mid-November to mid-April in Israel, coinciding with the rainy season (Palm, 1987).
- Conidia are dispersed by wind and rain between trees and adjacent orchards (Solel, 1976).
- Long-distance spread of mal secco occurs through the movement of infected propagative material and plants (Laviola & Scarito, 1989). Interstate quarantine controls are in-place on the movement of nursery plants in Australia. Restrictions are in place on movement of budwood from Queensland.
- Birds and insects are suspected to be vectors of *Phoma tracheiphila* (Perrotta & Graniti, 1988).

Probability of entry, establishment or spread

The overall likelihood that *Phoma tracheiphila* will enter Australia as a result of trade in sweet oranges from Italy, 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 probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of the *Phoma tracheiphila*: **Moderate**.

Criterion	Estimate
Direct consequences	
Plant life or health	**D** — In the Mediterranean region, *Phoma tracheiphila* is the most destructive fungal disease of citrus. Up to 100% of trees of susceptible cultivars in lemon orchards can be affected (Perrotta & Graniti, 1988). The disease reduces the quantity and quality of citrus produced in the area where the pathogen is present, and limits the use of susceptible species and cultivars. Reduction in lemon yield in Italy has resulted in estimated annual losses of more than US$ 160 million (Palm, 1987). The disease not only lowers production but also kills trees.
Any other aspects of the environment	**B** — There are no known direct consequences of this pathogen on any other aspects of the environment. The fungus may affect native citrus (*Eremocitrus* spp. and *Microcitrus* spp.). The consequences are unlikely to be discernible at a national level.
Indirect consequences	
Eradication, control, etc.	**D** — Programs to minimise the impact of this fungus on host plants are likely to be costly and include fungicidal applications and crop monitoring. No satisfactory genetic or chemical control measures are available for *Phoma tracheiphila*. Tolerant lemon cultivars have been selected in Italy but they lack the productivity and fruit quality of standard cultivars (Solel & Salerno, 2000). Therefore, eradication or control of this pathogen is likely to be significant at the regional level, if it were to establish.
Domestic trade	**C** — The presence of *Phoma tracheiphila* in commercial citrus production areas may have a significant effect due to possible interstate trade restrictions. These restrictions may lead to a loss of markets, which in turn would be likely to require industry adjustment.
International trade	**D** — The presence of *Phoma tracheiphila* in commercial citrus production areas may have a significant effect due to any limitations imposed on access to overseas markets while suitable phytosanitary management measures, where possible, are developed. This fungus is of quarantine concern to most regional plant protection organisations.
Environment	**A** — Fungicides required to control *Phoma tracheiphila* are estimated to have consequences that are unlikely to be discernible at the national level and of minor significance at the local level.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for *Phoma tracheiphila*, determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Very low**.

4.2.2.3.4 Septoria spot

Species of *Septoria*, including *S. citri*, *S. depressa* and *S. limonium*, have been reported to cause septoria spot of citrus. Bonde *et al*. (1991) compared culture collections from

Australia and the USA and concluded that there was only one species involved in the disease – *Septoria citri*. Leaf and fruit spots caused by *Septoria* spp. have been reported from most citrus-growing regions in the world where they are generally considered to be of minor significance (Timmer *et al*., 2000). Nevertheless, damage to fruit rind often causes concern as the appearance of fresh fruit is important (Timmer *et al*., 2000).

The pathogen examined in this extension of existing policy is:

- **Septoria citri* Pass. – septoria spot.

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

Introduction and spread probability

Probability of importation

The likelihood that *Septoria citri* will arrive in Western Australia with the importation of sweet oranges from Italy: **Low**.

- *Septoria citri* is associated with citrus in Italy (AAN, 1998).
- Infected fruits show circular, dark, sunken reddish-brown spots, 1 to 2 mm in diameter (Agosteo, 2002) surrounded by a reddish brown halo as fruit mature, as well as coalescing lesions that may resemble a tear stain pattern or blemish (Adaskaveg *et al*., 2004).
- Infection occurs when the fruit is green, and symptoms become more conspicuous as the fruits ripen (Timmer *et al*., 2000).
- Infections may remain quiescent or not visible until the plant tissue becomes senescent or the natural resistance of the host is lowered from environmental injury such as frost or cold damage. Once the host tissue is weakened, the fungus is able to invade the tissue (Adaskaveg *et al*., 2004).
- Infected fruit exhibiting symptoms of septoria spot (Agosteo, 2002) would be rejected during harvesting and routine grading operations.
- Post-harvest grading, washing and packing procedures are likely to significantly reduce the number of spores on the surface of healthy fruit.

Probability of distribution

The likelihood that *Septoria citri* will be distributed to the endangered area as a result of the processing, sale or disposal of sweet oranges from Italy: **Low**.

- If sweet oranges were imported, they would be distributed in Australia for retail sale, as the intended use of the commodity is human consumption. Waste material would be generated.
- *Septoria citri* is likely to survive storage and transportation (Adaskaveg *et al*., 2004).
- It is unlikely the fungus would survive for long periods in discarded waste, as infected fruit would rot quickly in dumpsites, landfills and compost heaps due to the activity of saprophytic organisms.
- The fungus could form pycnidia in fruit lesions (Adaskaveg *et al*., 2004). The distance conidia could spread from infected fruit residues is limited, as conidia are dispersed by water splash.

Probability of entry (importation x distribution)

The likelihood that *Septoria citri* will enter Western Australia as a result of trade in sweet oranges from Italy and be distributed in a viable state to the endangered area: **Very low**.

- The overall probability of entry is determined by combining the probabilities of importation and distribution using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Probability of establishment

The likelihood that *Septoria citri* 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**.

- *Septoria citri* has a restricted host range on *Citrus* spp., but lemon and grapefruit are more susceptible (Timmer *et al*., 2000).
- Natural hosts, including susceptible *Citrus* species, are widely distributed in Western Australia, both in commercial orchard districts and suburban areas.
- *Septoria citri* is established in Australia (except WA), Argentina, Greece, Italy, California (Adaskaveg *et al*., 2004) and Africa, India, Israel and New Zealand (CABI, 2004). Environments similar to these areas exist in various parts of Western Australia.
- Pycnidia of *S. citri* often form profusely on dead citrus twigs, leaves (Timmer *et al*., 2000) and fruit lesions (Adaskaveg *et al*., 2004).
- The disease appears most commonly after cool or frosty weather and is usually more severe during years when rainfall levels are higher than normal. Low or fluctuating temperatures are thought to predispose citrus tissue to infection or the development of disease symptoms (Timmer *et al*., 2000).
- Application of copper or zinc based fungicides prior to rainfall is used to manage and control this fungus (Adaskaveg *et al*., 2004). Copper and zinc fungicides completely inhibit germination of conidia of the fungus (Adaskaveg *et al*., 2004).

Probability of spread

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

- *Septoria citri* spreads in tropical and Mediterranean type climates (Adaskaveg *et al*., 2004), and similar environments exist in various parts of Western Australia.
- Natural hosts, including susceptible *Citrus* species, are widely distributed in Western Australia, both in commercial orchard districts and suburban areas.
- The long distances between the main citrus production districts in Western Australia would make it difficult for this fungus to move directly from one district to another by natural spread.
- Conidia are produced by pycnidia present in infected host tissues, including twigs, leaves and fruit (Adaskaveg *et al*., 2004).
- During cool, wet weather or during sprinkler irrigation, the spores are splashed onto leaves and fruit where they can directly infect leaf tissue or fruit rind (Adaskaveg *et al*., 2004).

Probability of entry, establishment or spread

The overall likelihood that *Septoria citri* will enter Western Australia as a result of trade in sweet oranges from Italy, be distributed in a viable state to suitable hosts, establish in that area and subsequently spread within Western Australia: **Very low**.

- The probability of entry, establishment or spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of 'rules' for combining descriptive likelihoods (Table 3).

Consequences

Consequences (direct and indirect) of *Septoria citri*: **Low**.

Criterion	Estimate
Direct consequences	
Plant life or health	**C** — Although septoria spot is generally considered of minor importance, superficial spots may occur on the fruit rind. Thus, the disease affects fruit quality (Adaskaveg *et al*., 2004).
Any other aspects of the environment	**A** — There are no known direct consequences of these pathogens on the natural or built environment.
Indirect consequences	
Eradication, control, etc.	**A** — Programs to minimise the impact of this disease on host plants are not likely to be more costly than existing management measures.
Domestic trade	**A** — The presence of this disease in commercial production areas will have a minor effect at the local level as there will be no interstate trade restrictions on citrus as the pathogen is already present in parts of eastern Australia.
International trade	**A** — The presence of this disease in commercial citrus production areas will have a minor effect at the local level due to any limitations to access to overseas markets where this pathogen is absent.
Environment	**A** — Additional fungicide applications might be required to control this disease on citrus. This is unlikely to affect the environment.

Note: Refer to Table 4 (The assessment of local, district, regional and national consequences) and text under the 'Method for assessing consequences' section for details on the method used for consequence assessment.

Unrestricted risk estimate

The unrestricted risk estimate for *Septoria citri* determined by combining the overall 'probability of entry, of establishment and of spread' with the 'consequences' using the risk estimation matrix (Table 5): **Negligible**.

4.2.3 Risk assessment conclusion

Table 7 summarises the detailed risk assessments and provides unrestricted risk estimates for the quarantine pests considered to be associated with sweet oranges from Italy.

Mediterranean fruit fly was assessed to have an unrestricted risk estimate of moderate. Pink citrus rust mite, citrophilus mealybug, citrus pyralid, citrus flower moth, western flower thrips and predatory mites (phytoseiid mites and stigmaeid mites) were assessed to have unrestricted risk estimates of low. The unrestricted risk estimates for these pests exceed Australia's appropriate level of protection. Specific risk management measures are therefore required for the import of sweet oranges from Italy into Australia to adequately address the potential quarantine risk.

Citrus red mite, yellow mite, scales and whiteflies and the fungi *Nematospora coryli*, *Phytophthora palmivora, Phytophthora syringae, Phoma tracheiphila* and *Septoria citri* were assessed to have an unrestricted risk of negligible or very low and therefore do not require the application of any specific phytosanitary measures in order to maintain Australia's appropriate level of protection.

Table 7: Unrestricted risk summary

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					
ARTHOPODS								
Pink citrus rust mite	High	Low	Low	Moderate	Moderate	Low	Moderate	**Low**
Citrus red mite	High	Low	Low	Moderate	Moderate	Low	Low	Very low
Yellow mite	High	Low	Low	High	Moderate	Low	Low	Very low
Mediterranean fruit fly	High	Moderate	Moderate	High	Moderate	Low	High	**Moderate**
Citrophilus mealybug	High	Moderate	Moderate	High	High	Moderate	Low	**Low**
Scales	High	Low	Low	High	Moderate	Low	Low	Very low
Whiteflies	High	Low	Low	High	Moderate	Low	Low	Very low
Citrus pyralid	Moderate	Low	Low	High	High	Low	Moderate	**Low**
Citrus flower moth	Moderate	Low	Low	High	High	Low	Moderate	**Low**
Western flower thrips	High	Moderate	Moderate	High	High	Moderate	Low	**Low**
PREDATORY MITES								
Phytoseiid mites	High	Low	Low	Moderate	Moderate	Low	Moderate	**Low**
Stigmaeid mites	High	Low	Low	Moderate	Moderate	Low	Moderate	**Low**
PATHOGENS								
Brown spot	Low	Low	Very low	High	High	Very low	Low	Negligible
Dry fruit rot	Low	Low	Very low	High	High	Very low	Low	Negligible
Mal Secco	Low	Low	Very low	High	High	Very low	Moderate	Very low
Septoria spot	Low	Low	Very low	Moderate	High	Very low	Low	Negligible

Table 8 provides the final list of quarantine pests of sweet oranges from Italy that have been assessed to have an unrestricted risk estimate above Australia's ALOP. These pests require the use of risk management measures in addition to the standard practices used in the production of commercial sweet oranges in Italy to meet Australia's ALOP. The recommended risk management measures are described in the following section.

Table 8: Quarantine pests of sweet oranges from Italy assessed to have unrestricted risk estimates above Australia's ALOP

Pest Type	Common name
ARTHROPODS	
Aculops pelekassi (Keifer) [Acari: Eriophyidae]	Pink citrus rust mite
Ceratitis capitata (Wiedemann) [Diptera: Tephritidae]	Mediterranean fruit fly
Cryptoblabes gnidiella (Millière) [Lepidoptera: Pyralidae]	Citrus pyralid
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips
Prays citri Millière [Lepidoptera: Yponomeutidae]	Citrus flower moth
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug
PREDATORY MITES	
Amblydromella rhenanoides (Athias-Henriot) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius aberrans (Oudemans) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius barkeri (Hughes) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius degenerans (Berlese) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius italicus Chant [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius potentillae (Garman) [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius stipulatus Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite
Amblyseius swirskii Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite
Eryngiopus bifidus Wood [Acari: Stigmaeidae]	Stigmaeid mite
Eryngiopus siculus Vacante & Gerson [Acari: Stigmaeidae]	Stigmaeid mite
Neoseiulus californicus McGregor [Acari: Phytoseiidae]	Phytoseiid mite
Typhlodromus exhilaratus Ragusa [Acari: Phytoseiidae]	Phytoseiid mite
Typhlodromus talbii Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite
Zetzellia collyerae (Gonzalez-Rodriguez) [Acari: Stigmaeidae]	Stigmaeid mite
Zetzellia graeciana Gonzalez [Acari: Stigmaeidae]	Stigmaeid mite
Zetzellia mali (Ewing) [Acari: Stigmaeidae]	Stigmaeid mite

4.3 Stage 3: Pest Risk Management

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests assessed to have an unrestricted risk estimate above Australia's ALOP via the importation of commercially produced sweet oranges from Italy, i.e. fruit from commercial production sites and subjected to standard cultivation, harvesting and packing activities.

It is important to note that it is only appropriate for the unrestricted risk estimates to take into account the minimum border procedures used by relevant government agencies and not those measures approved by such agencies that are 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 contaminations of containers and packaging. In order to have least trade restrictive measures, evaluation of restricted risk management options started with consideration of the use of a 600-unit inspection in detecting quarantine pests requiring risk management, and the subsequent remedial actions or treatments that might be applied if a quarantine pest is intercepted.

The standard AQIS sampling protocol requires inspection of 600 units, for quarantine pests in systematically selected random samples per homogeneous consignment or lot. The unit for citrus is defined as one 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. If no live quarantine pests are detected in the sample, the consignment is considered to be free from quarantine pests and would be released from quarantine. Where a quarantine pest is intercepted in a sample, the remedial actions or treatments may (depending on the location of the inspection) include:

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

It should be emphasised that inspection is not a measure that mitigates the risk of a pest. It is the remedial actions or treatment that can be taken based on the results of the inspection that would reduce a pest risk.

Biosecurity Australia considers that the risk management measures described in this document will provide an appropriate level of protection against the pests identified in the risk assessment.

Biosecurity Australia has considered stakeholders comments on the draft extension of existing policy to develop the risk management measures. Biosecurity Australia considers that the risk management measures below are commensurate with the identified risks and the measures form the basis of final import conditions for sweet oranges from Italy.

4.3.1 Risk management measures and phytosanitary procedures

The measures described below form the basis of the final import conditions for sweet oranges from Italy. These measures are described in Section 5 entitled Final Import Conditions.

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

- cold treatment for Medfly;
- inspection and remedial action for pink citrus rust mite, citrophilus mealybug, citrus pyralid, citrus flower moth, western flower thrips and predatory mites; and
- operational systems for the maintenance and verification of the phytosanitary status of sweet oranges.

4.3.1.1 Cold treatment for Mediterranean fruit fly

Mediterranean fruit fly (Medfly) has been assessed to have an unrestricted risk estimate of moderate and measures are therefore required to manage this risk.

Visual inspection of fruit alone is not considered to be an appropriate risk management measure because clear visual external signs of infestation (particularly in recently infested fruit) may not be present. If infested fruit was not detected at inspection, Medfly may enter, establish or spread in Australia.

Cold treatment is the measure that will be applied to manage the risk posed by Medfly. It is a disinfestation treatment that is able to mitigate the level of risk by killing live fruit fly eggs and larvae present in infested fruit. Citrus fruit from Spain, Egypt and Israel is permitted entry into Australia with a cold treatment applied pre-export or in-transit that is effective against Medfly. The disinfestation schedule is presented in Table 9.

Table 9: Cold disinfestation schedule

Temperature	Exposure Period (days)
0.0°C (32°F) or below	10
0.6°C (33°F) or below	11
1.1°C (34°F) or below	12
1.7°C (35°F) or below	14
2.2°C (36°F) or below	16

The above table forms the cold disinfestation treatment schedule for all Medfly host produce being imported into or exported from Australia under AQIS requirements.

Before this cold disinfestation treatment can be used to treat sweet oranges from Italy, it will be necessary to confirm operational arrangements for the application of the treatment and for the maintenance and verification of the phytosanitary status of the sweet oranges in a manner acceptable to Australia, based on Australia’s appropriate level of protection.

Subject to the necessary verifications and confirmations outlined above, the risk of entry, establishment or spread of Medfly associated with the importation of sweet oranges from Italy following cold treatment, as described above, would be negligible.

In the absence of the necessary verifications and confirmations outlined above, the risk of entry, establishment or spread of Medfly associated with the importation of sweet oranges from Italy following cold treatment as described above would be greater than very low (but would not exceed the unrestricted risk estimate of moderate). This is because treatment failure, either via inadequate application of the treatment or system failure via inadequate operational arrangements to maintain and verify the phytosanitary status of the sweet oranges, is likely to result in the presence of live fruit fly eggs or larvae in the fruit. The likelihood of this occurring depends on the nature and extent of the failure.

4.3.1.2 Visual inspection and remedial action for pink citrus rust mite, citrophilus mealybug, citrus pyralid, citrus flower moth, western flower thrips and predatory mites

Pink citrus rust mite, citrophilus mealybug, citrus pyralid, citrus flower moth, western flower thrips and predatory mites have been assessed to have unrestricted risk estimates of low and measures are therefore required to manage this risk.

Visual inspection will involve the examination of a sample of sweet orange fruit to detect the presence of the pink citrus rust mite, citrophilus mealybug, citrus pyralid, citrus flower moth, western flower thrips and predatory mites.

Remedial action when pests are present is recommended as an appropriate risk management option for these pests, given that trained inspectors can readily detect these pests. Methyl bromide fumigation is currently used by AQIS to control arthropod pests detected during on-arrival inspections. Methyl bromide is commonly used at a treatment rate of $32g/m^3$ for 2 hours at temperatures of 21°C or above, with an increase of $8g/m^3$ for each decrease of 5°C or less in temperature.

The objective of this measure is to ensure that consignments of sweet oranges from Italy infested with these pests can be identified and subjected to appropriate remedial action. This measure is considered to reduce the risk associated with pink citrus rust mite, citrophilus mealybug, citrus pyralid, citrus flower moth, western flower thrips and predatory mites to a very low level.

4.3.1.3 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 sweet oranges from Italy is maintained and verified during the process of production and export to Australia. Biosecurity Australia recommends a system that is equivalent to the systems currently in place for the importation of citrus from Spain, Egypt and Israel. Details of the system, or equivalent, will be determined by agreement with MPAF.

The system of operational procedures for the production and export of sweet oranges from Italy to Australia will include:

- registration of export orchards;

- registration of packinghouses and auditing of procedures;
- packaging and labelling;
- specific conditions for storage and movement of produce;
- pre-export phytosanitary inspection by MPAF;
- phytosanitary certification by MPAF; and
- on-arrival quarantine clearance by AQIS.

4.3.1.3a Registration of export orchards

All sweet oranges exported from Italy must be sourced from registered export orchards. Copies of the registration records must be available for audit by AQIS if requested. MPAF will be required to register each export orchard prior to commencement of exports from that orchard.

The hygiene of export orchards must be maintained by appropriate pest management options that have been approved by MPAF, to manage pests and diseases of quarantine concern to Australia. Registered growers must keep records of control measures for auditing purposes. If required, the details of the pest control program will be submitted to Biosecurity Australia/AQIS through MPAF.

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

4.3.1.3b Registration of packinghouses and auditing of procedures

All packinghouses intending to export fruit to Australia will be required to be registered with MPAF for trace-back purposes.

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

4.3.1.3c Packaging and labelling

All sweet oranges for export must be free from regulated articles[1] and pests of quarantine concern to Australia. No unprocessed packing material of plant origin will be allowed. All wood material used in packaging of sweet oranges must comply with the AQIS conditions, as set out in 'Cargo containers: quarantine aspects and procedures'.

All boxes must be labelled with the orchard registration number. The 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.

The objectives of this procedure are to ensure that:

- The sweet oranges exported to Australia are not contaminated by regulated articles and pests of quarantine concern to Australia; and

[1] The IPPC defines a 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'.

- Unprocessed packing material is not imported with sweet oranges.

4.3.1.3d Specific conditions for storage and movement

Packed product and packaging is to be protected from pest contamination during and after packing, during storage and during movement between locations (that is, packinghouse to cool storage/depot, to inspection point, to export point).

Product for export to Australia that has been inspected and certified by MPAF must be maintained in secure conditions that will prevent mixing with fruit for domestic consumption or export to other destinations.

Security of the consignment is to be maintained until release from quarantine in Australia.

Arrangements for secure storage and movement of produce are to be developed by MPAF in consultation with Biosecurity Australia/AQIS.

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

4.3.1.3e Phytosanitary inspection by MPAF

MPAF will inspect all consignments in accordance with official procedures for all visually detectable quarantine pests and regulated articles. Sample rates must achieve a confidence level of 95% that not more than 0.5% of the units in the consignment are infested/infected. This equates to a level of zero unit infested by quarantine pests in a random sample size of 600 units from the homogenous lot in the consignment[2]. The 600-unit sample must be selected randomly from every lot[3] in the consignment.

Detection of live quarantine pests or regulated articles will result in failure of the consignment. If a consignment fails inspection by MPAF, the exporter will be given the option of treatment and re-inspection of the consignment or removal of the consignment from the export pathway.

Records of the interceptions made during these inspections (live or dead quarantine pests, and regulated articles) are to be maintained by MPAF 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.

4.3.1.3f Phytosanitary certification by MPAF

MPAF will issue a phytosanitary certificate for each consignment after completion of the pre-export phytosanitary inspection. The objective of this procedure is to provide formal documentation to AQIS verifying that the relevant measures have been undertaken offshore. Each phytosanitary certificate is to contain the following additional declaration:

> *The sweet oranges in this consignment have been produced in Italy in accordance with the conditions governing entry of sweet oranges to Australia and inspected and found free of quarantine pests*

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[2] A consignment is the number of boxes of sweet oranges in a shipment from Italy to Australia covered by one phytosanitary certificate.

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

consistent with International Standards for Phytosanitary Measures No. 7 *Export Certification Systems* (FAO, 1997).

4.3.1.3g On-arrival phytosanitary inspection by AQIS

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. No land bridging of goods will be permitted unless goods have cleared quarantine.

Consignments will be inspected by AQIS using the standard AQIS inspection protocol. The detection of live quarantine pests and/or regulated articles will result in the failure of the inspection lot[4].

AQIS inspectors are trained to detect all life stages of arthropod pests, including eggs. On arrival inspections are conducted in accordance with AQIS work procedures, which include optical enhancement where necessary.

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

4.3.2 Action for non-complying lots

Where inspection lots are found to be non-compliant with requirements, remedial action must be taken as outlined at the beginning of this section. If product continually fails inspection, Biosecurity Australia/AQIS reserves the right to suspend the export program and conduct an audit of the citrus risk management systems in Italy. The program will recommence only after Biosecurity Australia/AQIS is satisfied that appropriate corrective action has been taken.

4.3.3 Uncategorised pests

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

[4] An inspection lot is the number of boxes presented for a single phytosanitary inspection.

5 FINAL IMPORT CONDITIONS

The final import conditions described below are based on the conclusions of the pest risk analysis contained in this final report. Specifically, they reflect the recommended risk management measures in the previous section.

The components of the final import conditions are summarised in dot point format below and the risk management measure that links with each component is given in brackets ( ).

- Registration of export orchards (4.3.1.3a)
- Registration of packinghouses and auditing of procedures (4.3.1b)
- Orchard control program (4.3.1.3a)
- Pre-export cold treatment (4.3.1.1)
- Packing and labelling (4.3.1.3c)
- Storage (4.3.1.3d)
- Pre-export phytosanitary inspection (4.3.1.3e)
- Phytosanitary certification (4.3.1.3f)
- On-arrival phytosanitary inspection by AQIS (4.3.1.3g)
- Review of protocol

5.1 Registration of Export Orchards

Sweet oranges for export to Australia must be sourced from orchards registered with MPAF. Copies of the registration records must be made available to AQIS if requested. Registration by MPAF is required to enable trace-back in the event of non-compliance.

All export orchards are expected to produce commercial sweet oranges under Italy's commercial cultivation, harvesting and packing practices.

5.2 Registration of Packinghouses and Auditing of Procedures

All packinghouses intending to export fruit to Australia must be registered with the MPAF, for trace-back purposes.

Packinghouses must identify individual orchards with a numbering system and identify fruit from individual orchards by marking cartons or pallets (one orchard per pallet) with a unique orchard number. The packinghouse and packing area would need to be well lit, and the storage areas will need to be secure to ensure fruit is not infested after packing.

Packing procedures must ensure that the sweet oranges are free of pests of concern to Australia and regulated articles.

MPAF 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 process.

The list of registered packinghouses must be kept by MPAF and provided to AQIS prior to exports commencing, with updates provided if packinghouses are added or removed from the list. A sample of growers and packinghouses are to be audited by MPAF at agreed intervals to ensure compliance with Biosecurity Australia requirements. This would be performed initially on an annual basis until the effectiveness of the system can be assessed.

5.3 Orchard Control Program

Registered growers must implement an orchard control program (i.e. good agricultural practice/integrated pest management (IPM) programs for export sweet oranges) that has been approved by MPAF, incorporating field sanitation and appropriate biocontrol and/or pesticide/fungicide applications for the management of pests and diseases of quarantine concern to Australia. MPAF will be responsible for ensuring that growers are aware of pests of quarantine concern to Australia, and that export orchards are subject to field sanitation and control measures against these pests. Registered growers must keep records of control measures for auditing purposes. If required, the details of the pest control program will be submitted to Biosecurity Australia/AQIS through MPAF.

If any pest of potential quarantine concern to Australia is detected, Biosecurity Australia/AQIS will require immediate notification by MPAF to ensure that appropriate action is taken.

5.4 Pre-export Cold Treatment

Cold treatment may be conducted in Italy or in-transit in containers designated by MPAF for such use. The temperature by time combinations specified in the treatment schedule as described under 4.3.1.1 are to be followed, recorded and monitored by MPAF. If treatment is conducted in containers, fruit must not be loaded until the pulp temperature of the fruit has reached the treatment temperature. If warehouses in Italy are used, MPAF will have to ensure the security of each consignment and check on the progress of the treatment.

5.5 Packing and Labelling

Sweet oranges must be packed into new cardboard boxes or cartons. No fresh or dried packing material of plant origin (e.g. straw) is to be used. Only processed or synthetic packing material can be used.

Each carton must identify the packinghouse and be labelled with a unique 'orchard' number to allow trace-back in the event of non-compliance.

5.6 Specific Conditions for Storage and Movement of Produce

MPAF must ensure that:

- registered packinghouses are maintained in a condition that would provide security against reinfestation/reinfection;
- the movement of sweet oranges from the time of arrival at the storage premises through to the time of export is recorded;
- records of sufficient detail to allow trace-back to orchard and packinghouse must be available to AQIS through MPAF, if required; and
- packinghouses to keep records to facilitate auditing by MPAF during grading, packing and storage.

Fruit inspected and certified by MPAF for export to Australia must be stored under quarantine security and segregated by at least one metre from all other fruit in a cold store until loaded into refrigerated containers. MPAF must ensure that container doors are sealed after loading.

Non-compliance with any of the above requirements will result in suspension of the facility by MPAF until corrective action has been completed and AQIS has agreed to reinstate the facility.

5.7 Pre-export Inspection and Remedial Action

MPAF will inspect all consignments in accordance with AQIS procedures for all visually detectable quarantine pests and regulated articles[5]. The AQIS sampling protocol requires inspection of 600 units for quarantine pests, in systematically selected random samples per homogeneous consignment[6] or lot[7]. 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. For citrus, AQIS defines a unit as one fruit.

The detection of live 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 of the consignment and re-inspection to ensure that the pest is no longer viable.

The export program to Australia will be suspended if any live Mediterranean fruit flies are detected in cold disinfested fruit, until Biosecurity Australia and MPAF are satisfied that appropriate corrective action has been taken.

Records of the interceptions made during these inspections (live quarantine pests and regulated articles) must be maintained by MPAF 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.

5.8 Phytosanitary Certification

MPAF will issue an International Phytosanitary Certificate (IPC) for each consignment upon completion of pre-export inspection and cold treatment for Medfly disinfestation, containing the following information:

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5 The IPPC defines a 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’.

6 A consignment is the number of boxes of sweet oranges in a shipment from Italy to Australia covered by one phytosanitary certificate.

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

Additional declarations

- Additional declaration stating: *'The sweet oranges in this consignment have been produced in Italy in accordance with the conditions governing entry of sweet oranges to Australia and inspected and found free of quarantine pests'*.

Distinguishing marks

- The appropriate 'orchard' numbers, packinghouse identification, number of cartons per 'inspection lot', container and seal numbers, and date.

Treatments

- For cold treatment: method of treatment (pre-shipment or in-transit), treatment temperature, duration and dates of treatment.

5.9 On-arrival Inspection, Remedial Action and Clearance by AQIS

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. No land bridging of goods will be permitted unless goods have cleared quarantine.

Consignments will be inspected by AQIS using the standard AQIS inspection protocol. The detection of live quarantine pests and/or regulated articles will result in the failure of the inspection lot.

AQIS inspectors are trained to detect all life stages of arthropod pests, including eggs. On arrival inspections are conducted in accordance with AQIS work procedures, which include optical enhancement where necessary.

The sampling methodology in the AQIS inspection protocol provides 95% confidence that there is not more than 0.5% infestation in the consignment. The sample size for inspection of sweet oranges is given below.

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

* Unit = one sweet orange 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.

5.9.1 Remedial action

If live quarantine pests or regulated articles are found during an inspection, the importer will be given the option to treat (if a suitable treatment is available), re-export or destroy the consignment.

Methyl bromide fumigation is currently used by AQIS to control arthropod pests detected during on-arrival inspections. Methyl bromide is commonly used at a treatment rate of $32 g/m^3$ for 2 hours at temperatures of 21°C or above, with an increase of $8 g/m^3$ for each decrease of 5°C or less in temperature.

5.9.2 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 clarification by MPAF and determination by AQIS, with the options of re-export or destruction. MPAF will be notified immediately by AQIS of any such problems.

5.10 Audit of Protocol

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

5.11 Review of Policy

This policy will be reviewed at the end of the first year of export of sweet oranges from Italy to Australia and in the event of new outbreaks in Italy of pests of quarantine concern to Australia.

6 CONCLUSIONS

The findings of this final import policy are based on a comprehensive analysis of relevant available scientific literature and existing import requirements for citrus from Egypt, Israel and Spain.

Biosecurity Australia considers that the risk management measures recommended in the final import policy will provide an appropriate level of protection against the pests identified in the PRA.

7 STAKEHOLDER COMMENTS ON THE DRAFT EXTENSION OF EXISTING POLICY REPORT

Biosecurity Australia circulated the draft report for the extension of existing policy for sweet oranges from Italy on 4 March 2005 and invited to comment on the technical issues raised in the draft report by 4 April 2005.

Biosecurity Australia received six written responses, four from Australian State Departments of Agriculture, one from an industry association and one from the Ministero Della Politiche Agricole e Forestali (Table 10).

Table 10: Stakeholders responding to the draft extension of existing policy report

Organisation	Representative	Date received
Ministero Della Politiche Agricole e Forestali	Roberto Mengoni – First Secretary	04/03/05
Department of Primary Industries – Biosecurity Victoria	Peter J Bailey – Executive Director	04/04/05
Australian Citrus Growers Inc.	Leonie Burrows – Executive Director	05/05/05
Department of Agriculture Western Australia	Shashi Sharma – Program Manager	08/05/05
Department of Primary Industries and Fisheries – Queensland	Jim Varghese – Director General	11/05/05
Department of Primary Industries – New South Wales	B.D. Buffier – Director General	16/06/05

Comments were received relating to a number of pests and their categorisation, including regional freedom status, the methodology used in the extension of existing policy, the treatment of predatory mites and the results of the risk ratings attributed to certain pests.

These comments were considered and material matters raised have been incorporated into, or addressed in, this final report for the extension of existing policy for sweet oranges from Italy. Biosecurity Australia would like to thank all those who provided comments, as these assist in ensuring that the risk assessment process is technically accurate and rigorous.

Detailed responses to these comments have been prepared and are available on the public file held by Biosecurity Australia.

REFERENCES

AAN (1998). Agricole ed Agroindustriali Nazionali, Direczione generale della politicje, Ministero per le Politiche Agricole. Lista completa dei parassiti degli agumi presenti in Italia.

Abou-Setta, M.M. and Childers, C.C. (1991). Intrinsic rate of increase over different generation time intervals of insect and mite species with overlapping generations. Annals of Entomological Society of America 84: 517-521.

Adaskaveg, J. E., O'Connell, N., Freeman, M., Kallsen, C., Mauk, P. and Faber, B. (2004). Citrus Notes: 1. University of California Cooperative Extension.

Agosteo, G.E., (2002). First report of Septoria spot on bergamot. Plant Disease 86: 71.

Aguilar, H. and Childers, C.C. (2000). Tydeidae (Acari: Prostigmata) on Florida citrus, pp 751-753. Proceedings of International Society of Citriculture, IX Conference.

AICN (2004). Australian Insect Common Names database. http://www.ento.csiro.au/aicn

Allen, W.R., Matteoni, J.A. and Broadbent, A.B. (1990). Susceptibility of cultivars of florist's chrysanthemum to tomato spotted wilt virus. Canadian Journal of Plant Pathology 12: 417-423.

Alvella, M., Fournier, D., Pralavorio, M. and Berge, J.B. (1985). Selection pour la resistance a la deltamethrine d'une souche de *Phytoseiulus persimilis* Athias-Henriot. Agronomie 5: 177-180.

Ascher, K.R.S., Eliyahu, M., Gurevitz, E. and Renneh, S. (1983). Rearing the honeydew moth, *Cryptoblabes gnidiella*, and the effect of diflubenzuron on its eggs. Phytoparasitica 11: 195–198.

Ashihara, W., Kondo, A., Shibao, M., Tanaka, H., Hiehata, K. and Izumi, K. (2004). Ecology and control of eriophyid mites injurious to fruit trees in Japan. JARQ 38: 31-41. http://www.jircas.affrc.go.jp

Balachowsky, A.S. (1966). Entomologie appliquée à l'agriculture Tome II, Vol. I. Masson et Cie, Paris, France. pp 563-578.

Balachowsky, A.S. (1972). Entomologie appliquée a l'agriculture. Tome II. Masson et Cie, Paris, France. pp 1059–1634.

Beardsley Jr., J.W. and Gonzalez, R.H. (1975). The biology and ecology of armoured scales [Diaspididae]. Annual Review of Entomology 20: 47-73.

Ben-Dov, Y. (1994). A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance. Intercept Limited, Andover, UK. 686 pp.

Bolland, H.R., Gutierrez, J. and Flechtmann, C.H.W. (1998). World Catalogue of the Spider Mite Family (Acari: Tetranychidae). K. Brill, Leiden, Netherlands. 392 pp.

Bonde, M. R., Peterson, G. L., Emmett, R. W. and Menge, J. A. (1991). Isozyme comparisons of *Septoria* isolates associated with citrus in Australia and the United States. Phytopathology 81: 517-521.

Brassier, C.M. and Griffin, M.J. (1979). Taxonomy of *Phytophthora palmivora* on cocoa. Transactions of the British Mycological Society 72: 111-143.

Brodsgaard, H.F. (1994). Insecticide resistance in European and African strains of western flower thrips (Thysanoptera: Thripidae) tested in a new residual-on-glass test. Journal of Economic Entomology 87: 1141-1146.

Brooks, R.F. and Knapp, J.L. (1983). Control of chaff scale on 'Dancy' tangerine. Proceedings of the Florida State Horticultural Society 96: 367-369.

Brown, G.E. (2003). Brown rot: Causal organisms and disease cycle. pp 133 Plant Pathology Department. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu/CH109

Bryan, D.E. and Smith, R.F. (1956). The *Frankliniella occidentalis* complex in California. University of California, Publications in Entomology 10:359-410.

Burditt, A.K., Jr. and Reed, D.K. (1963). Damage caused by *Aculops pelekassi* Keifer, a rust mite of citrus. Proceedings of Florida State Horticultural Society 76: 41-47.

Byrne, D.N., Bellows, T.S., Jr. and Parrella, M.P. (1990). Whiteflies in agricultural systems pp 227-261. In: Gerling, D. (ed.) Whiteflies: their Bionomics, Pest Status and Management. Intercept Limited, Andover, UK.

CABI (2004). Crop Protection Compendium (2004 edition). CAB International, Wallingford, UK. http://www.cabicompendium.org/cpc/home.asp

CABI/EPPO (1997). Quarantine Pests for Europe – Data sheets on quarantine pests for the European Union and for the European and Mediterranean Plant Protection Organization. Smith, I.M., McNamara, D.G., Scott, P.R. and Holderness, M. (Editorial Committee); Burger, B. (Associate Editor). CAB International, Wallingford, UK, in association with the European and Mediterranean Plant Protection Organization (EPPO).

Carter, D.J. (1984). Pest Lepidoptera of Europe with special reference to the British Isles. Dordrecht, Netherlands.

Carvalho, J.P. de, and Aguiar, A.M.F. (1997). Pragas dos citrinos na ilha da Madeira. Madeira, Spain: Direccao Regional de Agricultura da Regiao Autonoma da Madeira. 411 pp.

Castagnoli, M. Simoni, S. and Nachman, G. (2001). Short-term changes in consumption and oviposition rates of *Neoseiulus californicus* strain (Acari: Phytoseiidae) after a diet shift. Experimental and Applied Acarology 25: 969-983.

Cayol, J.P., Causse, R., Louis, C. and Barthes, J. (1994). Medfly *Ceratitis capitata* Wiedemann (Diptera: Trypetidae) as a rot vector in laboratory conditions. Journal of Applied Entomology 117: 338-343.

Childers, C.C. and Achor D.S. (1995). Thrips feeding and oviposition injuries to economic plants, subsequent damage, and host responses to infestation, pp 31 – 51. In: Parker, A.S, Skinner M. and Lewis, T. (eds) Thrips Biology and Management. Plenum, New York.

Childers, C.C. and Fasulo, T.R. (1995). Citrus red mite. Department of Entomology and Nematology, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Publication No. ENY-817.

Childers, C.C., McCoy, C.W., Nigg, H.N. and Stansly, P.A. (2004). 2005 Florida citrus pest management guide: Rust mites, spider mites and other phytophagous mites. Department of Entomology and Nematology, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Publication No. ENY-603.

Christenson, L.D. and Foote, R.H. (1960). Biology of fruit flies. Annual Review of Entomology 5: 171-192.

Clements, D.R. and Harmsen, R. (1990). Predatory behaviour and pre-stage preferences of stigmaeid and phytoseiid mites and their potential compatibility in biological control. Canadian Entomologist 122: 321-328.

Clements, D.R. and Harmsen, R. (1992). Stigmaeid-phytoseiid interactions and impact of natural enemy complexes on plant-inhabiting mites. Experimental and Applied Acarology 14: 327-341.

Cloyd, R.A. and Sadof, C.S. (2003). Western Flower Thrips. http://www.agcom.purdue.edu/AgCom/Pubs/index.html

Croft, B.A. (1994). Biological control of apple mites by a phytoseiid mite complex and *Zetzella mali* (Acri: Stigmaeidae): Long-term effects and impact of Azinphosmethyl on colonization by *Amblyseius andersoni* (Acrai: Phytoseiidae). Environmental Entomology 23: 1317-1325.

Croft, B.A. and Barnes, M.M. (1971). Comparative studies on four strains of *Typhlodromus occidentalis*. III. Evaluation s of release of insecticide resistant strains into an apple orchard ecosystem. Journal of Economic Entomology 64: 845-850.

Croft, B.A. and Jung, C. (2001). Phytoseiid dispersal at plant to regional levels: a review with emphasis on management of *Neoseiulus fallacis* in diverse agroecosystems. Experimental and Applied Acarology 25: 763-784.

Croft, B.A. and MacRae, I.V. (1993). Biological control of apple mites by a phytoseiid mite complex and *Zetzellia mali* (Acari: Stigmaeidae) on *Typhlodromus pyri* and *Metaseiulus occidentalis* (Acari: Phytoseiidae). Environmental Entomology 22: 865-873.

Croft, B.A., MacRae, I.V. and Currans, K.G. (1992). Factors affecting biological control of apple mites by a mixed population of *Metaseiulus occidentalis* and *Typhlodromus pyri*). Experimental and Applied Acarology 14: 343-355.

Davidson, R.H. and Lyon, W.F. (1987). Insect pests of farm, garden, and orchard. John Wiley & Sons, New York, USA. 8 xiii + 640 pp.

Davies, F.S. and Albrigo, L.G. (1994). Citrus. Crop production science in horticulture 2. Weeds, Pests and Diseases. CABI International, Wallingford, UK.

De Jager, K. and Daneel, M.S. (1999). Protect banana bunches against pests with bags. Neotropical Bulletin 305: 32–33.

De Lima, F. (1998). Ecological studies of the Mediterranean fruit fly for area wide control in South Australia. 5th International symposium on fruit flies of economic importance. 129 pp.

De Lima, F., Woods, W. and Broughton, S. (1993). Control of Mediterranean fruit fly (medfly) in backyards. Department of Agriculture Western Australia. Farmnote No. 4/93. Agdex 201/622.

Dicke, M. (1994). Local and systemic production of volatile herbivore-induced terpenoids: Their role in plant-carnivore mutualism. Journal of Plant Physiology 143: 465-472.

Dicke, M., Beck, T.A., van, Posthumus, M.A., Ben Dom, N. van Bokhoven, H. and de Groot, A.E. (1990). Isolation and identification of a volatile kairomone that effects acarine predator-prey interaction: involvement of host plant in its production. Journal of Chemical Ecology 16: 381-396.

Dicke, M., Sabelis, M. W., and Groeneveld, A. (1986). Vitamin A deficiency modifies response of predatory mite *Amblyseius potentillae* to volatile kairomone of two-spotted spider mite, *Tetranychus urticae*. Journal of Chemical Ecology 12: 1389-1396.

Dreistadt, S.H., Clark, J.K. and Flint, M.L. (1994). Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide. Agriculture and Natural Resources Publication 3359. University of California, Oakland, California, USA.

Duso, C. and Vettorazzo, E. (1999). Mite population dynamics on different grape varieties with and without phytoseiids release (Acari: Phytoseiidae). Experimental and Applied Acarology 23: 741-763.

EPPO (2002). PQR database (version 4.1). European and Mediterranean Plant Protection Organization, Paris, France.

EPPO (2004). Citrus: Good plant protection practice. European and Mediterranean Plant Protection Organization. OEPP/EPPO Bulletin 34: 43-56.

Erwin, D.C. and Ribeiro, O.K. (1996). Phytophthora Diseases Worldwide. St. Paul, Minnesota, USA: American Phytopathological Society Press.

FAO (1997). International Standards for Phytosanitary measures No 7: Export Certification System. Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome.

FAO (2002). International Standards for Phytosanitary measures No 5: Glossary of Phytosanitary Terms. Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome.

Fasulo, T.R. and Brooks, R.F. (2001). Scale pests of Florida citrus. Entomology and Nematology. Department, Florida Cooperative Extension Services, Institute of Food and Agricultural Sciences, University of Florida. Fact Sheet ENY-814.

Fawcett, H. S. (1929). *Nematospora* on pomegranates, citrus and cotton in California. Phytopathology 19: 479-482.

Fawcett, H. S. (1936). Citrus diseases and their control. McGraw-Hill: New York.

Fimmiani, P. (1989). Mediterranean Region. In: Robinson, A.S. and Hooper, G. (eds.) Fruit Flies their Biology, Natural Enemies and Control. pp 39-50. World Crop Pests. Elsevier Elsevier Science Publishers, Amsterdam, Netherlands.

Fletcher, B.S. (1989). Ecology; movements of tephritid fruit flies. In: Robinson, A.S., and Hooper, G, (eds.) Fruit Flies; Their Biology, Natural Enemies and Control. pp 209-219. World Crop Pests. Elsevier Science Publishers, Amsterdam, Netherlands.

Foldi, I. (1990). The scale cover. In: Rosen, D. (ed.) Armoured scale insects; Their Biology, Natural Enemies and Control. pp 43-57. World Crop Pests. Elsevier Science Publishers, Amsterdam, Netherlands.

Garrido, A. and Ventura, J.J. (1993). Plagas de los cítricos. Bases para el manejo integrado. M.A.P.A., Madrid, Spain.

Gerling, D., and Horowitz, A.R. (1984). Yellow traps for evaluating the population levels and dispersal patterns of *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae). Annals of the Entomological Society of America 77: 753-759.

Gerson, U. (1980). The scale insect *Parlatoria paranoid* Comstock and its natural enemies in Israel. Seminar on biological control of scale insects and aleurodids on citrus. Boletin del Servicio de Lucha Biologica Contra Plagas e Inspeccion Fitopatoloica 21: 21-53.

Gillespie, D.R. and Ramey, C.A. (1988). Life history and cold storage of *Amblyseius cucumeris* (Acarina: Phytoseiidae). Journal of Entomological Society of British Colombia 85: 71-76.

Gilstrap, F. E. and Friese, D. D. (1985). The predatory potential *of Phytoseiulus persimilis*, *Neoseiulus californicus*, and *Metaseiulus occidentalis* (Acarina: Phytoseiidae). International Journal of Acarology 11: 163–168.

Gnanvossou, D., Hanna, R. and Dicke, M. (2002). Prey-related odor performance of the predatory mites *Typhlodromalus manihotis* and *Typhlodromalus aripo* (Acari: Phytoseiidae). Experimental and Applied Acarology 27: 39-56.

Graham, J.H. and Timmer. L.W. (2003). Phytophthora diseases of citrus. SL 127. Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu/CH087

Hall, D.G. and Simms, M.K. (2003). Damage by infestations of Texas citrus mite (Acari: Tetranychidae) and its effect on the life of 'Valencia' leaves in an irrigated citrus grove. Florida Entomologist 86: 15- 28.

Hamon, A.B. (2001). Whitefly of citrus in Florida. Florida Department of Agriculture and Consumer Service, Division of Plant Industry, Gainesville, Florida, USA.

Hanks, L.M. and Denno, R.F. (1994). Local adaptation in the armoured scale insect *Pseudaulacaspis pentagona* (Homoptera: Diaspididae). Ecology 75: 2301-2310.

Hashem, A.G., Tadros, A.W. and Abo-Sheasha, M.A. (1997). Monitoring the honeydew moth, *Cryptoblabes gnidiella* Miller in citrus, mango and grapevine orchards (Lepidoptera: Pyralidae). Annals of Agricultural Science Cairo 42: 335–343.

Helle, W. and Sabelis, M.W. (1985). Spider Mites – Their biology, natural enemies and control. World Crop Pests. Volume 1B, Elsevier Science Publishers, Amsterdam, Netherlands.

Hely, P. C., Pasfield, G. and Gellatley, G. J. (1982). Insect pests of fruit and vegetables in New South Wales. Inkata Press, Melbourne.

Hislop, R.G. and Prokopy, R.J. (1981). Mite predator responses to prey and predator-emitted stimuli. Journal of Chemical Ecology 7: 895-904.

Hoddle, M.S. (2000). Using *Neoseiulus californicus* for control of Persea mite. California Avocado Research Symposium. University of California, Riverside.

Holiday, P. (1980). Fungus diseases of tropical crops. Cambridge University Press, Cambridge. pp 126-127.

Howarth, F.G. (1991). Environmental impacts of classical biological control. Annual Review of Entomology 36: 485-510.

Hoy, L.E. and Whiting, D.C. (1997). Low temperature storage as a post-harvest treatment to control *Pseudococcus affinis* (Homoptera: Pseudococcidae) on royal gala apples. Journal of Economic Entomology 90: 1377-1381.

Hoy, M.J., Groot, J.J., and van de Baan, H.E. (1985). Influence of aerial dispersal on persistence and spread of pesticide –resistant Metaseiulus occidentalis in California almond orchards. Entomologia Experimental and Applied 90: 191-198.

Hoyt, S.C. (1969). Integrated chemical control of insects and biological control of mites on apples in Washington. Journal of Economic Entomology 62: 74-86.

Huang, L. L., Wang, D. W., Zhang, Q. B., and Zhu, W. S. (1983). A study on the biology and control of the arrowhead scale (*Unaspis yanonensis* Kuwana). Proceedings of the International Society of Citriculture 2: 640-643.

HYPP (2004a). Citrus flower moth. http://www.inra.fr/Internet/Produits/HYPPZ/RAVAGEUR/

HYPP (2004b). Mediterranean fruit fly. http://www.inra.fr/Internet/Produits/HYPPZ/RAVAGEUR/6cercap.htm

Ibrahim, S.S. and Shahateh, W.A. (1984). Biological studies on the citrus flower moth *Prays citri* Miller in Egypt. Arab Journal of Plant Protection 2: 4-9.

Ippolito, A., Cicco, De, V., Cutuli, G. and Salerno, M. (1987). The role of infected citrus fruits and seeds in the spread of mal secco disease. In: Proceedings of 7Th Congress of the Mediterranean Phytopathology Union, Granada, Spain. pp 166-167.

Izquierdo, J., Mansanet, V., Sanz, J.V. and Puiggros, J.M. (2002). Development of Envidor^{R} for the control of spider mites in Spanish citrus production. Planzenschutz-Nachrichten Bayer 55: 255-266.

Jeppson, L.R., Keifer, H.H. and Baker, E.W. (1975). Mites Injurious to Economic Plants. University of California Press, Berkeley, USA.

Johnson, D.T. and Croft, B.A. (1976). Laboratory study of the dispersal behaviour of *Amblyseius fallacis* (Acari: Phytoseiidae). Annals of Entomological Society of America 69: 1019-1023.

Johnson, D.T. and Croft, B.A. (1981). Dispersal of *Amblyseius fallacis* (Acari: Phytoseiidae) in an apple ecosystem. Environmental Entomology 10: 313-319.

Johnson, S. (2004). Biology and behaviour of western leaf-footed bug on Satsuma orange in Louisiana. http://esa.confex.com/esa/2004/techprogram/paper_17209.htm

Johnson, W.T. and Lynon, H.H. (1991). Insects that feed on trees and shrubs. 2nd Edition. Comstock Publishing Associates 560 pp.

Jones, R. (1993). Tomato spotted wilt and impatient necrotic spot viruses spread by thrips. Department of Agriculture, Western Australia, Farmnote 41/93. http://agaspsrv34.agric.wa.gov.au/agency/Pubns/farmnote/1993/F04193.htm

Jones, V.P. and Parrella, M.P. (1984). Intra-tree regression sampling plans for the citrus red mite (Acari: Tetranychidae) on lemons in southern California. Journal of Economic Entomology 77: 810-813.

Karban, R., English-Loeb, G., Walker, M.A. and Thaler, J. (1995). Abundance of phytoseiid mites on *Vitis* species: effects of leaf hairs, domatia, prey abundance and plant phenology. Experimental and Applied Acarology 19: 189-197.

Karsholt, O. (1996). The Lepidoptera of Europe: A Distributional Checklist. Apollo Books, Stenstrup, Denmark.

Knapp, J.L. (1998). The Mediterranean fruit fly. Entomology and Nematology. Department, Florida Cooperative Extension Services, Institute of Food and Agricultural Sciences, University of Florida. Fact Sheet ENY-809.

Korkmaz, S., Kersting, U., Ertugrul, B. and Cinar, A. (1996). Transmission and epidemiology of citrus chlorotic dwarf (CCD) disease in the eastern Mediterranean region of Turkey. Journal of Turkish Phytopathology 25: 71-76.

Kostiainen, T.S. and Hoy, M.A. (1996). The Phytoseiidae as biological control agent of pest mites and insects: A bibliography, University of Florida, Agricultural Experimental Station, Monograph 17, 355 pp.

Krantz. G.W. (1978). A manual of Acarology. Corvallis, Oregon State University, Oregon, 509 pp.

Laviola, C. and Scarito, G. (1989). Distance and direction of dissemination of *Phoma tracheiphila* (Petri) Kanc. Et Ghik. propagules. Phytopathologia Mediterranea 28:161-163.

Lawson, D.S., Nyrop, J.P. and Dennehy, T.J. (1996). Aerial dispersal of European red mite (Acari: Tetranychidae) in commercial apple orchards. Experimental and Applied Acarology 20: 193-202.

Liburd, O.E., Seferina, G.G. and Dinkins (2003). Suppression of two-spotted mites. In: UF/IFAS, Berry/Vegetable Times, November.

Linquist, E.E. and Oldfield, G.N. (1996). Evolution of eriophyid mites in relation to their host plants, pp173-183. In: Linquist, E.E. Sabelis, M.W. and Bruin, J (eds.) Eriophyid mites – Their Biology, Natural Enemies and Control. World Crop Pest Series, vol 6. Elsevier Publishing, Amsterdam, The Netherlands.

Liotta, G. and Mineo, G. (1964). La *Cryptoblabes gnidiella* Miller o tignola rigata degli agrumi (Lepidoptera: Pyralidae) osservazioni biologiche in Sicilia. *Bollettino 1st* Entomologia Agraria e dell'Osservatorio di Fitopatologia di Palermo 5: 155–172.

Llusia, J. and Penuelas, J. (2001). Emission of volatile organic compounds by apple trees under spider mite attack and attraction of predatory mites. Experimental and Applied Acarology 25: 65-77.

Lublinkhof, J. and Foster, D.E. (1977). Development and reproductive capacity of *Frankliniella occidentalis* (Thysanoptera: Thripidae) reared at three temperatures. Journal of the Kansas Entomological Society 50:313-316.

Ludwig, S. and Oetting, R. (2001). Effect of Spinosad^{R} on Orius insidiosus (Hemiptera: Anthocoridae) when used for Frankliniella occidentalis (Thysanoptera: Thripidae) control on greenhouse pot chrysanthemums. Florida Entomologist 84: 311-313.

Luh, H.K. and Croft, B.A. (2001). Quantitative classification of life-style types in predaceous phytoseiid mites. Experimental and Applied Acarology 25: 403-424.

Malais, M.H. and Ravensberg, W.J. (2003). Knowing and recognizing: the biology of glasshouse pests and their natural enemies. Koppert B.V. and Reed Business Information. 288 pp.

Marullo, R. (2002). Impact of imported pest thrips on the indigenous natural history and agricultural systems of southern Italy. Thrips and topsoviruses, pp 285-288. Proceedings of the 7Th International Symposium on Thysanoptera.

McClure, M.S. (1983). Reproduction and adaptation of exotic hemlock scales (Homoptera: Diaspididae) on their new and native hosts. Environmental Entomology 12: 1811-1815.

McDonald, J.R., Bale, J.S. and Walters, K.F.A. (1997). Effects of sub-lethal cold stress on the western flower thrips, *Frankliniella occidentalis*. Annals of Applied Biology 131: 189-195.

McMurtry, J.A. (1982). The use of phytoseiids for biological control: progress and future prospects, pp 23-48. In: Hoy, M. (ed.) Recent advances in knowledge of the Phytoseiidae. University of California Press, Berkley. Publication No 3284.

McMurtry, J.A. and Croft, B.A. (1997). Life styles of phytoseiid mites and their role as biological control agents. Annual Review of Entomology 42: 291-321.

Meats, A.W., Clift, A.D. and Robson, M.K. (2003). Incipient founder populations of Mediterranean and Queensland fruit flies in Australia: the relation of trap catch to infestation radius and models for quarantine radius. Australian Journal of Experimental Agriculture 43: 397-406.

Mendonca, T.R., Martins, F.M. and Lavadinho, A.M.P. (1997). Curvas de voo da traca do limoeiro, *Prays citri* (Milliere) (Lepidoptera: Yponomeutidae) num pomar de limoeiros en mafra e evolucao do grao de ataque. Boletin de Sanidad Vegetal Plagas 23: 479-483.

Metcalf, R.L. (1995). The need for research on exotic pests in California. In: Morse, J.G., Metcalf, R.L., Carey, J.R. and Dowell, R.V. (eds). The Medfly in California: Defining critical research. pp. 5 –39. Center for Exotic Pest Research, University of California, Riverside.

Meyerdirk, D.E. and Moreno, D.S. (1984). Flight behaviour and colour-trap preference of *Parabemisia myricae* (Kuwana) (Homoptera: Aleyrodidae) in a citrus orchard. Environmental Entomology 13: 167-170.

Mijuskovic, M. (1973). The study of mites on the citrus trees on the Yugoslavia littoral. Final technical report. Agriculture Research Institute, Titograd, Yugoslavia. 239 pp.

Mijuskovic, M. and Kosac, D. (1972). Control of *Aculops pelekassi* Keifer (Acaria: Eriophyidae), an important mite injurious to citrus on the coast of Montenegro. Jugoslovenskog Vocarstva 21-22: 835-845.

Mijuskovic, M. and Velimirovic, V. (1971). The damage to citrus by *Aculops pelekassi* Keifer (Acaria: Eriophyidae). Poljoprivreda I Sumarstvo 17: 105-114.

Miller, D.R., Miller, G.L., and Watson, G.L. (2002). Invasive species of mealybugs (Hemiptera: Pseudococcidae) and their threat to US Agriculture. Proceedings of the Entomological Society of Washington 104: 825-836.

Mineo, G. (1967). Notes on the behavior of *Prays citri* Millière (Lepidoptera: Yponomeutidae). Bollettino dell 'Instituto di Entomologia Agraria e dell' Osservatorio di Fitopatologia di Palermo 7: 277-282.

Mineo, G., Sciacchitano, M.A. and Sinacori, A. (1991). Observations on the phenology of the preimaginal stages of *Prays citri* Mill. (Lepidoptera: Hyponomeutidae). Redia 74: 225–232.

Mound, L. A., and Teulon, D. A. J. (1995). Thysanoptera as phytophagous opportunist, pp 3-19. In: Parker, B.L. Skinner, M. and Lewis, T. (eds.) Thrips Biology and Management. New York.

Mound, L.A. and Halsey, S.H. (1978). Whitefly of the world: A systematic catalogue of the Aleyrodidae (Homoptera) with host plant and natural enemy data. British Museum (Natural History) Publication No. 787. 340 pp.

Mukerji, K. G. (1968). *Nematospora coryli*. CMI descriptions of plant pathogenic fungi and bacteria 184.

Muma, M.M. and Selhime, A.G. (1971). *Agistemus floridanus* (Acarina: Stigmaeidae) a predatory mite on Florida citrus. Florida Entomologist 54: 249-258.

Nielsen, G.R. (2003). Eriophyid mites. The University of Vermont Extension Leaflet 144. http://www.uvm.edu/extesnion/publications/el/el144.htm

Nielsen, E.S. and Edwards, E.D. (1996). Checklist of the Lepidoptera of Australia. CSIRO, Canberra, Australia.

Nohara, K. (1962). Studies on the biology of *Unaspis yanonensis*. Science Bulletin of the Faculty of Agriculture, Kyushu University, No. 20.

Ohkubo, N. (1980). Ecology and control of the arrowhead scale, *Unaspis yanonensis* Kuwana. Review of Plant Protection Research 13: 1-11.

Orphanides, G.M. (1991). Biology and biological control of *Parabemisia myricae* (Kuwana) (Homoptera: Aleyrodidae) in Cyprus. Technical Bulletin No. 135. Agricultural Research Institute, Cyprus. 6 pp.

Palm, M.E. (1987). Pests not known to occur in the United States or of limited distribution. No. 91. *Phoma tracheiphila*. APHIS, USDA.

Paulson, G.S. and Beardsley, J.W. (1986). Development, oviposition and longevity of *Aleurothrixus floccosus* (Maskell) (Homoptera: Aleyrodidae). Proceedings of the Hawaiian Entomological Society 26: 97–99.

PDI (2003). Pest Interception Records up to 31 December 2002. Pest and Disease Information Database. Australian Government Department of Agriculture, Fisheries and Forestry, Canberra, Australia.

Perrotta, G. and Graniti, A. (1988). *Phoma tracheiphila* (Petri). Kantschaveli et Gikashvili, pp 396-398.. In: Smith, I.M., Dunez, J., Lelliot, R.A., Phillips, D.H. and Archer, S.A. (eds) European Handbook of Plant Diseases. Blackwell Scientific Publications, Oxford, UK.

Pfleger, F.L., Ascerno, M.E. and Wawrzynski, R. (1995). Tomato spotted wilt virus. Minnesota Commercial Flower Growers Bulletin 44: 1-7.

Ploetz, R.C., Lim, T.K., Menge, J.A., Kenneth, G., Rohrbach, K.G. and Michaolides, T.J. (2003). Diseases of Tropical Fruit Crops, pp 1-19. In: Ploetz, R.C. (ed.) Common pathogens of tropical fruit crops. CABI Publishing, Wallingford, UK.

Pratt, P. D., Schausberger, P. and Croft, B.A. (1999). Prey-food types of *Neoseiulus fallacis* (Acari: Phytoseiidae) and literature versus experimentally derived pre-food estimates for five phytoseiid species. Experimental and Applied Acarology 23: 551-565.

Punithalingam, E. and Holliday, P. (1973). *Deuterophoma tracheiphila* (Petri). Kantschaveli et Gikashvili. CMI Description of pathogenic fungi and bacteria. No 399.

QDPI (2003). Winning the war against papaya fruit fly. Queensland Department of Primary Industries Website. http://www.dpi.qld.gov.au/health/4639.html

Razak, A., Mohammad, P., Shiraishi, M. and Ono, H. (2000). SEM observations on the external features of pink rust mite, *Aculops pelekassi* (Keifer) [Acari: Eriophyidae]. Pakistan Journal of Biological Science 3: 725-730.

Reitz, S.R., and Trumble, J.T. (2002). Competitive displacement among insects and arachnids. Annual Review of Entomology 47: 435-465.

Reuther, W., Calavan, E. C. and Carman, G. E. (1978). The citrus industry. Vol. IV. Crop Protection. University of California, Berkeley, CA, USA.

Rondon, S.I., Price, J.F., Liburd, O.E., Francis, R. and Cantliffe, D.J. (2004). *Neoseiulus californicus* McGregor: A predatory mite species for controlling two-spotted spider mites in strawberries. HS 1001 Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu

Rose, M. and Rosen, D. (1991). *Eretmocerus debachi* n. sp. (Hymenoptera: Aphelinidae), an effective parasite of *Parabemisia myricae* (Homoptera: Aleyrodidae). Israel Journal of Entomology 25-26: 199-207.

Sabelis, M.W. (1985). Predation on spider mites., pp. 103-129. In: Helle, W. and Sabelis, M.W. (eds.) Spider mites, their biology, natural enemies and control. Volume 1B. Elsevier, Amsterdam.

Sabelis, M.W. and Janssen, A. (1993). Evolution of life-history patterns in the Phytoseiidae, pp. 70-98. In: Houck, M.A. (ed.), Mites: ecological and evolutionary analyses of life-history patters. Chapman & Hall, New York.

Sabelis, M.W. and Bruin, J. (1996). Evolutionary ecology: life history patterns, food plant choice, and dispersal, pp. 329-366. In: Linquist, E.E. Sabelis, M.W. and Bruin, J (eds.) Eriophyid mites – Their Biology, Natural Enemies and Control. World Crop Pest Series, vol 6. Elsevier Publishing, Amsterdam, The Netherlands.

Sabelis, M.W. and Van Rijn, P.C.J. (1997). Predation by insects and mites, pp 259-354. In: Lewis T. (ed.), Thrips as crop pests. CAB International, Wallingford.

Salinas, M.D., Sumalde, A.C., Calilung, V.J. and Bajet, N.B. (1996). Life history, seasonal abundance, host range and geographical distribution of the woolly whitefly, *Aleurothrixus floccosus* (Maskell) (Homoptera: Aleyrodidae). Philippine Entomologist 10: 67-89.

Santos, M. (1976). Evaluation of *Zetzellia mali* as a predator of *Panonychus ulmi* and *Aculus schlechtendali*. Environmental Entomology 5: 187-191.

Santos, M.A., and Laing, J.E. (1985). Stigmaeid predators, pp. 197-203. In: Helle, W. and Sabelis, M.W. (eds.) Spider mites: Their biology, natural enemies and control. Vol. 1B, Elsevier, Amsterdam.

Sato, M.E., Raga, A., Ceravolo, L.C., Filho, M.F. de Souza, Rossi, A.C. and de Moraes, G.J. (2001). Effect of insecticides and fungicides on the interaction between members of the mite families Phytoseiidae and Stigmaeidae on citrus. Experimental and Applied Acarology 25: 809-818.

Schvester, D. (1985). Insects and French forests. Revue Forestiere Françoise (Special Issue) 37: 45-64.

Seki, M. (1981). Life cycle of the pink citrus rust mite, *Aculops pelekassi* (Keifer), in Japan. Proceedings of the International Society of Citriculture. pp. 656-658.

Sengonca, C., Uygun, N., Kersting, U. and Ulusoy, M.R. (1993). Successful colonization of *Eretmocerus debachi* (Hymenoptera: Aphelinidae) in the Eastern Mediterranean Citrus region of Turkey. Entomophaga 38: 383-390.

Shimoda, T., Takabayashi, J., Ashihara, W. and Takafuji, A. (1997). Response of predatory insect Scolothrips takahashii toward herbivore-induced plant volatiles under laboratory and filed conditions. Journal of Chemical Ecology 23: 2033-2048.

Shivas, R. G., Smith, M. W., Marney, T. S., Newman, T. K., Hammelswang, D. L., Cooke, A. W., Pegg, K. G. and Pascoe, I. A. (2005). First record of *Nematospora coryli* in Australia and its association with dry rot of *Citrus*. Australasian Plant Pathology 34: 99-101.

Siebert, J.A. (1994). Economic impact of an embargo by Japan, Korea, Taiwan and Hong Kong of selected exports due to Mediterranean fruit fly infestations. Department of Agriculture and Research Economics, University of California, Berkeley.

Silva, E.B. and Mexia, A. (1999). The pest complex *Cryptoblabes gnidiella* (Millière) (Lepidoptera: Pyralidae) and *Planococcus citri* (Risso) (Homoptera:

Pseudococcidae) on sweet orange groves (*Citrus sinensis* (L.) Osbeck) in Portugal: Interspecific association. Boletin de Sanidad Vegetal Plagas 25: 89–98.

Sinacori, A. and Mineo, N. (1997). Two new host plants of *Prays citri* and *Contarinia citri* (*Casimiroa edulis – Ligustrum lucidum* – Sicily). Informatore Fitopatologico 47: 13-15.

Singh, Y.P. and Singh, D.K. (1995). Bionomics of *Cryptoblabes gnidiella* Millèr. A pest of sorghum. Advances in Agricultural Research in India 3: 119–129.

Smith, D., Beattie, G.A.C. and Broadley, R. (1997a). Citrus pests and their natural enemies. Information series, Q197030. Queensland Department of Primary Industries, Brisbane.

Smith, I.M., McNamara, D.G., Scott, P.R., and Holderness, M. (1997b). Quarantine Pests for Europe. *Deuterophoma tracheiphila*, pp 733-736. Data sheets on quarantine pests for European Union and for the European and Mediterranean Plant Protection Organization. CAB International, Wallingford, UK.

Solel, Z. (1976). Epidemiology of mal secco disease of lemons. Phytopathologische Zeitschrift 85: 90-92.

Solel, Z. and Oren, Y. (1975). Outbreak of mal secco disease in Israel on normally tolerant citrus cultivars. Plant Disease Reporter 59: 945-946.

Solel, Z. and Salerno, M. (2000). Mal Secco pp 33-35. In: Timmer, L.W., Garnsey, S.M. and Graham, J.H. (eds) Compendium of Citrus Diseases. American Phytopathological Society, St. Paul, Minnesota.

Solomon, M.G., Cross, J.V., Fitzgerald, J.D., Campbell, C.A.M., Jolly, R.L., Olszak, R.W., Niemczyk, E. and Vogt, H. (2000). Biocontrol of pests of apples and pears in northern and central Europe – 3: Predators. Biocontrol Science and Technology 10: 91-128.

Soto, A., Ohlenschlaeger, F. and Garcia-Mari, F. (2002). Distribution and sampling of the whiteflies (*Aleurothrixus floccosus, Dialeurodes citri* and *Parabemisia myricae* (Homoptera: Aleyrodidae) in citrus in Spain. Journal of Economic Entomology 95: 167-173.

Stepanov, K.M. and Shaluishkina, V.I. (1952). Lemon fruit and seeds – sources of initial infectious desiccation. Microbiology Moscow 28: 48-51.

Sternlicht, M., Barzakay, I. and Tamim, M. (1990). Management of *Prays citri* by mass trapping of males. Alon Hanotea 34: 189-192.

Sweilem, S.M., El Bolok, M.M. and Abdel Aleem, R.Y. (1984). Biological studies on *Parlatoria ziziphus* (Lucas) (Homoptera – Diaspididae). Bulletin de la Societe Entomologique d’Egypte 65: 301-317.

Swirski, E., Blumberg, D., Wysoki, M. and Izhar, Y. (1985). Data on the phenology and biological control of the Japanese bayberry whitefly, *Parabemisia myricae*, in Israel. Phytoparasitica 13: 73.

Swirski, E., Izhar, Y., Wysoki, M., Gurevitz, E. and Greenberg, S. (1980). Integrated control of the long-tailed mealybug, *Pseudococcus longispinus* (Homoptera: Pseudococcidae), in avocado plantations in Israel. Entomophaga 25: 415-426.

Takabayashi, J. and Dicke, M. (1996). Plant-carnivore mutualism through herbivore-induced carnivore attractant. Trends in Plant Science 1: 109-113.

Taverner, P. and Bailey, P. (1995). Commercial trial of citrus post-harvest oil for removal of surface pests. South Australian Research and Development Institute Research Report Series, SARDI, South Australia.

Thévenin, J.M. (1994). Coconut Phytophthora diseases in Indonesia etiological aspects, pp 27-31. In: CIRAD-CP, (eds.), Coconut Phytophthora. Workshop Proceedings. Montpellier, France.

Thomas, M.C., Heppner, J.B., Woodruff, R.E., Weems, H.V., Steck, G.J. and Fasulo, T.R. (2001). Mediterranean fruit fly. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, EENY-214.

Timmer, L. W., Garnsey, S. M. and Graham, J. H. (2000). Compendium of citrus diseases. 2nd edition. APS Press, USA.

Timmer, L.W. and Duncan, L.W. (1999). Citrus health management. The American Phytopathological Society, St. Paul, Minnesota, USA. 197 pp.

Tixier, M., Kreiter, S., Auger, P. and Weber, M. (1998). Colonization of Languedoc vineyards by phytoseiid species: influence of wind and crop environment. Experimental and Applied Acarology 22: 523-542.

Tomkins, A.R., Wilson, D.J., Thomson, C. and Allison, P. (2000). Tydeid mites on Persimmons. New Zealand Plant Protection 53: 200-204.

Tono, T., Fujita, S. and Yamaguchi, S. (1978). Effect of infestation by citrus rust mite, *Aculops pelekassi* (Keifer), on development of satsuma mandarin fruit and availability for juice processing from damaged fruit. Agricultural Bulletin, Saga University 44: 57-66.

Tuttobene, R. (1993). Citrus mal secco. Informatore Fitopatologico 43: 25-30.

Tuttobene, R. (1994). Monitoring of *Phoma tracheiphila* inoculum. Difesa delle Piante 17: 69-74.

Uygun, N., Ohnesorge, B. and Ulusoy, R. (1990). Two species of whiteflies on citrus in eastern Mediterranean: *Parabemisia myricae* (Kuwana) and *Dialeurodes citri* (Ashmead). Morphology, biology, host plant and control in Turkey. Journal of Applied Entomology 110: 471-482.

Vacante, V. and Nucifora, A. (1986). A first list of the mites in citrus orchards in Italy, pp 177-188. In: Cavalloro, R., and Di Martino, E. (eds.). Integrated Pest Control in Citrus-Groves: Proceedings of the experts' meeting, Acireale, 26-29 March 1985. Rotterdam, Netherlands: Published for the Commission of the European Community by A.A. Balkema, Rotterdam/Boston.

Vacante, V. and Gerson, U. (1987). Three species of *Eryngiopus* (Acari: Stigmaeidae) from Italy, with key to species and summary of habitats. Redia 70: 385-401.

Vacante, V., Nucifora, A. and Garzia, G.T. (1988). Citrus mites in the Mediterranean area. Bulletin SROP 11: 39-49.

Van Lenteren, J.C. and Noldus, L.P.J.J. (1990). Whitefly-plant relationships: Behavioural and ecological aspects. In: Gerling, D. (ed.). Whiteflies: their Bionomics, Pest Status and Management. pp 47–89. Intercept Limited, Andover, UK.

Vet, L.E.M. and Dicke, M. (1992). Ecology of infochemical use by natural enemies in a tritrophic context. Annual Review of Entomology 37: 141-172.

Villanueva, R.T. and Childers, C.C. (2005). Diurnal and spatial patterns of Phytoseiidae in the citrus canopy. Experimental and Applied Acarology 35: 269-280.

Vulic, M. and Beltran, J.L. (1977). The whitefly *Aleurothrixus floccosus*, a serious pest of citrus crops. Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz 84: 202–214.

Walker, G.P. and Aitken, D.C.G. (1985). Oviposition and survival of bayberry whitefly, *Parabemisia myricae* (Homoptera: Aleyrodidae) on lemons as a function of leaf age. Environmental Entomology 14: 254–257.

Walzer, A. and Schausberger, P. (1999). Predation preference and discrimination between con-and heterospecific prey by the phytoseiid mites *Phytoseiulus permilis* and *Neoseiulus californicus*. Biocontrol 43: 469-478.

Waterhouse, G.M. and Waterston, J.M. (1964). *Phytophthora syringae*. CMI Descriptions of pathogenic fungi and bacteria no. 32. CABI International.

Weeden, C.R., Shelton, A.M., Li, Y. and Hoffmann, M.P. (2005). Biological control: A guide to natural enemies in North America. Cornell University. http://www.nysaes.cornell.edu/ent/biocontrol/

White, I.M. and Elson-Harris, M.M. (1994). Fruit Flies of Economic Significance; Their Identification and Bionomics. CAB International, Wallingford, UK.

White, N.D.G. and Laing, J.E. (1977a). Some aspects of the biology and laboratory life table of the acarine predator *Zetzellia mali*. Canadian Entomologist 109: 1275-1281.

White, N.D.G. and Laing, J.E. (1977b). Field observations of *Zetzellia mali* in Southern Ontario apple orchards Proceedings of the Entomological Society of Ontario 127: 99-106.

Willard, J.R. (1974). Horizontal and vertical dispersal of California red scale, *Aonidiella aurantii* (Mask.) (Homoptera: Diaspididae) in the field. Australian Journal of Zoology 22: 531-548.

Williams D.J. and Watson G.W. (1988). The Scale Insects of the Tropical South Pacific Region. Part 1. The Armoured Scales (Diaspididae). CAB International, Wallingford, UK.

Williams, D.J. (1996). A synoptic account of the mealybug genus *Ferrisia* Fullaway (Hemiptera: Pseudococcidae). Entomologist's Monthly Magazine 132: 1-10.

Woods, B. (1997). Mediterranean fruit fly eradication in Western Australia- Overview. Proceedings from the national Mediterranean fruit fly workshop Perth. pp 5-10.

Woolhouse, M.E.J. and Harmsen, R. (1984). The mite complex on foliage of a pesticide-free apple orchard population dynamics and habitat association. Proceedings of Entomological Society of Ontario 115: 1-11.

Wysoki, M. (1986). New records of Lepidopterous pests of macadamia in Israel. Phytoparasitica 14: 147.

Wysoki, M., Yehuda, S.B. and Rosen, D. (1993). Reproductive behaviour of the honeydew moth *Cryptoblabes gnidiella*. Invertebrate Reproduction and Development 24: 217-224.

Zhang, Z.Q and Sanderson, J.P. (1997). Patterns, mechanisms and spatial scale of aggregation in generalist and specialist predatory mites (Acari: Phytoseiidae). Experimental and Applied Acarology 21: 393-404.

Zhao, G., Liu, W., Brown, J.M., and Knowles, C.O. (1995). Insecticide resistance in field and laboratory strains of western flower thrips (Thysanoptera: Thripidae). Journal of Economic Entomology 88: 1164-1167.

Zitko, S.E., Timmer, L.W. and Sandler, H.A. (1991). Isolation of *Phytophthora palmivora* pathogenic to citrus in Florida. Plant Disease 75: 532-535.

APPENDIX – 1: PEST CATEGORISATION

1a: Pest Categorisation for Sweet Oranges from Italy - Presence/Absence

1b: Pest Categorisation for Sweet Oranges from Italy - Pathway Association

1c: Potential for Establishment or Spread and Associated Consequences for Pests of Sweet Oranges from Italy

Appendix – 1a: Pest Categorisation for Sweet Oranges from Italy – Presence/Absence

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
ARTHROPODS				
Acari (mites)				
Aceria sheldoni (Ewing) [Acari: Eriophyidae]	Bud mite	AAN, 1998	AICN, 2004	
Aculops pelekassi (Keifer) [Acari: Eriophyidae]	Pink citrus rust mite	AAN, 1998		**Yes**
Aculus schlechtendali (Nalepa) [Acari: Eriophyidae]	Apple rust mite	Ceparano & Job, 1996	AICN, 2004	
Aplonobia histricina (Berlese) [Acari: Tetranychidae]	Soursob mite	Vacante & Nucifora, 1986a	AICN, 2004; ICDB, 2002	
Brevipalpus californicus (Banks) [Acari: Tenuipalpidae]	Red flat mite	AAN, 1998	AICN, 2004; ICDB, 2002	
Brevipalpus cuneatus Canestrini & Fanzago [Acari: Tenuipalpidae]	False spider mite	AAN, 1998		[8]
Brevipalpus obovatus Donnadieu [Acari: Tenuipalpidae]	Privet mite	Vacante & Nucifora, 1986a	AICN, 2004	
Brevipalpus phoenicis (Geijskes) [Acari: Tenuipalpidae]	False spider mite	AAN, 1998	AICN, 2004; Williams, 2001	
Bryobia praetiosa Koch [Acari: Tetranychidae]	Almond mite	Vacante & Nucifora, 1986a	Halliday, 1998; Michael & Carmody, 2002	
Bryobia tunisiae Manson [Acari: Tetranychidae]		Vacante & Nucifora, 1986a		**Yes**
Daidalotarsonemus vandevrieri Suski [Acari: Tarsonemidae]	Tarsonemid mite	Vacante *et al*., 1988		**Yes**
Eupelops acromios (Hermann) [Acari: Phenopelopidae]	Oribatid mite	Vacante *et al*., 1988		**Yes**
Fungitarsonemus monasterii Lombardini [Acari: Tarsonemidae]	Tarsonemid mite	Vacante & Nucifora, 1986a		**Yes**
Glycyphagus domesticus (DeGeer) [Acari: Glycyphagidae]	House itch mite	Vacante & Nucifora, 1986a	AICN, 2004	
Hirstiella insignis Berlese [Acari: Pterygosomatidae]	Mite	Vacante *et al*., 1988		**Yes**
Humerobates rostrolamellatus Grandjean [Acari: Ceratozetidae]	Oribatid mite	Vacante & Nucifora, 1986a		**Yes**

[8] *Brevipalpus cuneatus* (synonym: *Caligonus cuneatus*) is a phytophagous species reported on lemon in Sicily in 1903. However, it was not found in the surveys conducted in 1986 (Vacante & Nucifora, 1986a). On the basis of this information, this mite is not considered further.

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Lorryia australensis (Baker) [Acari: Tydeidae]	Citrus yellow mite	Vacante & Nucifora, 1986a		**Yes**
Lorryia ferula Baker [Acari: Tydeidae]	Tydeid mite	Vacante & Nucifora, 1986a		**Yes**
Lorryia formosa Cooreman [Acari: Tydeidae]	Yellow mite	Vacante *et al*., 1988		**Yes**
Lorryia reticulata (Oudemans) [Acari: Tydeidae]	Reticulate mite	Vacante & Nucifora, 1986a		**Yes**
Lorryia teresae (Carmona) [Acari: Tydeidae]	Tydeid mite	Vacante & Nucifora, 1986a		**Yes**
Metalorryia magdalenae (Baker) [Acari: Tydeidae]	Tydeid mite	Vacante *et al*., 1988		**Yes**
Micreremus gracilior Willmann [Acari: Micremidae]	Oribatid mite	Vacante & Nucifora, 1986b		**Yes**
Orthotydeus californicus (Banks) [Acari: Tydeidae]	Tydeid mite	Vacante & Nucifora, 1986a	Smith *et al*., 1997; M. Poole pers comm. 2005	
Orthotydeus caudatus (Dugès) [Acari: Tydeidae]	Tydeid mite	Vacante & Nucifora, 1986a		**Yes**
Orthotydeus foliorum [Acari: Tydeidae]	Tydeid mite	Vacante & Nucifora, 1986a		**Yes**
Orthotydeus kochi Oudemans [Acari: Tydeidae]	Tydeid mite	Castagnoli, 1984		**Yes**
Panonychus citri McGregor [Acari: Tetranychidae]	Citrus red mite	AAN, 1998	AICN, 2004 (except WA)	**Yes**
Panonychus ulmi (Koch) [Acari: Tetranychidae]	European red mite	CABI, 2004	AICN, 2004; Botha & Learmonth, 2005	
Petrobia tunisiae Manson [Acari: Tetranychidae]	Spider mite	Vacante & Nucifora, 1986a		**Yes**
Phauloppia lucorum C. L. Koch [Acari: Oribatulidae]	Oribatulid mite	Vacante *et al*., 1988		**Yes**
Phyllocoptruta oleivora (Ashmead) [Acari: Eriophyidae]	Citrus rust mite	CABI, 2004	AICN, 2004; Woods *et al*., 1996	
Polyphagotarsonemus latus Banks [Acari: Tarsonemidae]	Broad mite	AAN, 1998	AICN, 2004	
Pronematus ubiquitus (McGregor) [Acari: Tydeidae]	Tydeid mite	Vacante & Nucifora, 1986a		**Yes**
Siculobata sicula Berlese [Acari: Oribatulidae]	Oribatulid mite	Vacante & Nucifora, 1986a		**Yes**
Tarsonemus aurantii Oudemans [Acari: Tarsonemidae]	Tarsonemid mite	Vacante & Nucifora, 1986a		**Yes**
Tarsonemus bilobatus Suski [Acari: Tarsonemidae]	Tarsonemid mite	Nucifora & Vacante, 2004		**Yes**
Tarsonemus confusus Ewing [Acari: Tarsonemidae]	Tarsonemid mite	Vacante *et al*., 1988		**Yes**
Tarsonemus floricolus Canestrini & Fanzago [Acari: Tarsonemidae]	Tarsonemid mite	Nucifora & Vacante, 2004		**Yes**
Tarsonemus idaeus Suski [Acari: Tarsonemidae]	Tarsonemid mite	Nucifora & Vacante, 2004		**Yes**

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Tarsonemus lobosus Suski [Acari: Tarsonemidae]	Tarsonemid mite	Nucifora & Vacante, 2004		**Yes**
Tarsonemus parawaitei Kim *et al*. [Acari: Tarsonemidae]	Tarsonemid mite	Vacante *et al*., 1988	Kim *et al*., 1987 (except WA)	**Yes**
Tarsonemus smithi Ewing [Acari: Tarsonemidae]	Tarsonemid mite	Vacante & Nucifora, 1986a		**Yes**
Tarsonemus unguis Ewing & Ewing [Acari: Tarsonemidae]	Tarsonemid mite	Vacante & Nucifora, 1986a		**Yes**
Tarsonemus waitei Banks [Acari: Tarsonemidae]	Tarsonemid mite	Vacante & Nucifora, 1986a	Smith *et al*., 1997 (except WA)	**Yes**
Tetranychina harti (Ewing) [Acari: Tetranychidae]	Spider mite	Ciampolini *et al*., 1985		**Yes**
Tetranychus urticae Koch [Acari: Tetranychidae]	Two spotted spider mite	AAN, 1998	AICN, 2004; ICDB, 2002	
Thyreophagus cooremani Fain [Acari: Acaridae]	Acarid mite	Vacante, 1989		**Yes**
Thyreophagus corticalis (Michael) [Acari: Acaridae]	Acarid mite	Vacante & Nucifora, 1986a		**Yes**
Thyreophagus entomophagus (Laboulbène & Robin) [Acari: Acaridae]	Thyreophagus flour mite	Vacante & Nucifora, 1986a	AICN, 2004	
Thyreophagus entomophagus italicus Vacante [Acari: Acaridae]	Acarid mite	Vacante, 1989		**Yes**
Thyreophagus gallegoi Portus & Gomez [Acari: Acaridae]	Acarid mite	Vacante, 1989		**Yes**
Trichoribates angustatus Mihelcic [Acari: Ceratozetidae]	Mite	Vacante & Nucifora, 1986a		**Yes**
Triophtydeus triophthalmus (Oudemans) [Acari: Tydeidae]	Tydeid mite	Vacante & Nucifora, 1986a		**Yes**
Tyrophagus neiswanderi Johnson & Bruce [Acari: Acaridae]	Acarid mite	Vacante, 1989		**Yes**
Tyrophagus palmarum (Oudemans) [Acari: Acaridae]	Acarid mite	Vacante *et al*., 1988		**Yes**
Tyrophagus putrescentiae (Schrank) [Acari: Acaridae]	Cereal mite	Vacante & Nucifora, 1986a	ICDB, 2002	
Tyrophagus tropicus Robertson [Acari: Acaridae]	Acarid mite	Vacante & Nucifora, 1986a		**Yes**
Coleoptera (beetles, weevils)				
Adalia bipunctata Linnaeus [Coleoptera: Coccinellidae]	Two-spotted ladybird	AAN, 1998	AICN, 2004	
Anoplophora chinensis (Forster) [Coleoptera: Cerambycidae]	Citrus longicorn beetle	Colombo & Limonta, 2001		**Yes**
Apate monachus Fabricius [Coleoptera: Bostrichidae]	Black borer	Benfatto & Longo, 1986		**Yes**
Aphtona nigriceps Redtb [Coleoptera: Chrysomelidae]	Chrysomelid beetle	Benfatto & Longo, 1986		**Yes**

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Araecerus coffeae (Fabricius) [Coleoptera: Anthribidae]	Coffee bean weevil	Mphuru, 1974	APPD, 2004	
Asynonychus cervinus (Boheman) [Coleoptera: Curculionidae]	Fuller's rose weevil	CABI, 2004	Smith *et al*., 1997	
Carpophilus hemipterus (Linnaeus) [Coleoptera: Nitidulidae]	Dried fruit beetle	Giudice & Lanza, 1973	James *et al*., 2000	
Carpophilus humeralis (Fabricius) [Coleoptera: Nitidulidae]	Pineapple sap beetle	Ciampolini & Maiulini, 1991	James et al., 1995	
Carpophilus mutilatus Erichson [Coleoptera: Nitidulidae]	Flower beetle	CABI, 2004	James *et al*., 2000	
Cetonia arurata Linnaeus [Coleoptera: Scarabeidae]	Flower weevil	Benfatto & Longo, 1986		**Yes**
Coccinella septempunctata Linnaeus [Coleoptera: Coccinellidae]	Seven-spotted ladybird	CABI, 2004		**Yes**
Crepidptera impressa Fabricius [Coleoptera: Chrysomelidae]	Chrysomelid beetle	Benfatto & Longo, 1986		**Yes**
Crepidptera ventralis [Coleoptera: Chrysomelidae]	Chrysomelid beetle	Benfatto & Longo, 1986		**Yes**
Cryptolaemus montrouzieri Mulsant [Coleoptera: Coccinellidae]	Mealybug ladybird	CABI, 2004	Booth & Pope, 1986	
Epitrix hirtipennis (Melsheimer) [Coleoptera: Chrysomelidae]	Tobacco flea beetle	CABI, 2004		**Yes**
Longitarsus brunneus Duft [Coleoptera: Chrysomelidae]	Chrysomelid beetle	Benfatto & Longo, 1986		**Yes**
Longitarsus tabidus Fabricius [Coleoptera: Chrysomelidae]	Chrysomelid beetle	Benfatto & Longo, 1986		**Yes**
Otiorhynchus armatus Bodenheimer [Coleoptera: Curculionidae]	Curculio weevil	Benfatto & Longo, 1986		**Yes**
Otiorhynchus cribricollis Gyllenhal [Coleoptera: Curculionidae]	Curculio weevil	AAN, 1998	AICN, 2004	
Otiorhynchus rhacusensis Germ. [Coleoptera: Curculionidae]	Curculio weevil	Benfatto & Longo, 1986		**Yes**
Oxythyrea funesta Poda [Coleoptera: Scarabeidae]	Scarabeid weevil	Benfatto & Longo, 1986		**Yes**
Pentodon punctatus Vill [Coleoptera: Scarabeidae]	Scarabeid weevil	Benfatto & Longo, 1986		**Yes**
Rhizotrogus rugifrons Burmeister [Coleoptera: Scarabaeidae]	Scarab beetle	Zanardi *et al*., 1979		**Yes**
Rodolia cardinalis Mulsant [Coleoptera: Curculionidae]	Vedalia ladybird	CABI, 2004	AICN, 2004	
Stethorus punctillum (Weise) [Coleoptera: Coccinellidae]	Mite eating ladybird	CABI, 2004		**Yes**
Synoxylon sexdentatum Oliver [Coleoptera: Bostrichidae]	Bostrichid beetle	Benfatto & Longo, 1986		**Yes**
Trichoferus griseus Fabricius [Coleoptera: Cerambycidae]	Cerambycid beetle	Benfatto & Longo, 1986		**Yes**
Tropinota hirta Poda [Coleoptera: Scarabeidae]	Scarabeid weevil	Benfatto & Longo, 1986		**Yes**
Tropinota squalida Scopoli [Coleoptera: Scarabeidae]	Scarabeid weevil	Benfatto & Longo, 1986		**Yes**

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Xylomedes coronata Mars [Coleoptera: Bostrichidae]	Bostrichid beetle	Benfatto & Longo, 1986		Yes
Dermaptera (Earwigs)				
Forficula auricularia Linnaeus. [Dermaptera: Forficulidae]	European earwig	Santini, 1995	AICN, 2004	
Diptera (flies)				
Ceratitis capitata (Wiedemann) [Diptera: Tephritidae]	Mediterranean fruit fly; Medfly	AAN, 1998	WA only (Under official control)	**Yes**
Syrphus spp. [Diptera: Syrphidae]	Hover fly	AAN, 1998		**Yes**
Hemiptera (aphids, leafhoppers, mealybugs, scales, true bugs, whiteflies)				
Aleurothrixus floccosus (Maskell) [Hemiptera: Aleyrodidae]	Woolly whitefly	Barbagallo *et al*., 1986		**Yes**
Aonidiella aurantii (Maskell) [Hemiptera: Diaspididae]	California red scale	AAN, 1998	AICN, 2004	
Aonidiella citrina (Coquillet) [Hemiptera: Diaspididae]	Citrus yellow scale	CABI/EPPO, 1998	AICN, 2004; Watson, 2004	
Aphis craccivora Koch [Hemiptera: Aphididae]	Cowpea aphid	AAN, 1998	APPD, 2004	
Aphis fabae Scopoli [Hemiptera: Aphididae]	Black bean aphid	AAN, 1998		**Yes**
Aphis gossypii Glover [Hemiptera: Aphididae]	Cotton aphid	AAN, 1998	APPD, 2004[9]	
Aphis spiraecola Patch [Hemiptera: Aphididae]	Brown citrus aphid	CABI/EPPO, 2001	APPD, 2004	
Aspidiotus nerii Bouché [Hemiptera: Diaspididae]	Aucuba scale	AAN, 1998	AICN, 2004; Abbot, 1995	
Asymmetrasca decedens (Paoli) [Hemiptera: Cicadellidae]	Green leafhopper	AAN, 1998		**Yes**
Bemisia afer (Priesner & Hosny) [Hemiptera: Aleyrodidae]	Whitefly	Barbagallo *et al*., 1986	Martin, 1999 (except WA)	**Yes**
Bemisia tabaci biotype B (Gennadius) [Hemiptera: Aleyrodidae]	Tobacco whitefly	Barbagallo *et al*., 1986	APPD, 2004 (Under official control in WA)	**Yes**
Brachycaudus helichrysi (Kaltenbach) [Hemiptera: Cicadellidae]	Plum aphid	Bassi, 1994	AICN, 2004	
Calocoris trivialis (Costa) [Hemiptera: Miridae]	Mirid bug	AAN, 1998		**Yes**
Ceroplastes floridensis Comstock [Hemiptera: Coccidae]	Florida wax scale	Ben-Dov, 1993	AICN, 2004 (except WA)	**Yes**

[9] This aphid is a known vector of citrus tristeza virus (CTV). However, CTV has been eradicated from Italy; therefore, this vector was not considered further.

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Ceroplastes japonicus Green [Hemiptera: Coccidae]	Japan wax scale	Pellizzari & Camporese, 1994		**Yes**
Ceroplastes rusci (Linnaeus) [Hemiptera: Coccidae]	Fig tree scale	AAN, 1998	AICN, 2004 (except WA)	**Yes**
Ceroplastes sinensis Del Guercio [Hemiptera: Coccidae]	Chinese wax scale	AAN, 1998	AICN, 2004	
Chrysomphalus aonidum (Linnaeus) [Hemiptera: Diaspididae]	Citrus black scale	CABI, 2004	APPD, 2004	
Chrysomphalus dictyospermi (Morgan) [Hemiptera: Diaspididae]	Palm scale	AAN, 1998	AQIS, 1994 (except WA)	**Yes**
Coccus hesperidum Linnaeus [Hemiptera: Coccidae]	Brown scale	AAN, 1998	APPD, 2004	
Coccus pseudomagnoliarum (Kuwana) [Hemiptera: Coccidae]	Citricola scale	AAN, 1998	AICN, 2004	
Dialeurodes citri (Ashmead) [Hemiptera: Aleyrodidae]	Citrus whitefly	Barbagallo *et al*., 1986		**Yes**
Diaspidiotus perniciosus (Comstock) [Hemiptera: Diaspididae]	San Jose scale	EPPO, 2004	AICN, 2004	
Dysmicoccus brevipes (Cockerell) [Hemiptera: Pseudococcidae]	Pineapple mealybug	CABI, 2004	AICN, 2004	
Hemiberlesia lataniae (Signoret) [Hemiptera: Diaspididae]	Lataniae scale	CABI, 2004	AICN, 2004	
Icerya purchasi Maskell [Hemiptera: Margarodidae]	Fluted scale	AAN, 1998	APPD, 2004	
Lepidosaphes beckii (Newman) [Hemiptera: Diaspididae]	Purple scale	AAN, 1998	AICN, 2004	
Lepidosaphes gloverii (Packard) [Hemiptera: Diaspididae]	Glover's scale	Longo & Russo, 1986	AICN, 2004 (except WA)	**Yes**
Macrosiphum euphorbiae (Thomas) Hemiptera: Aphididae]	Potato aphid	AAN, 1998	APPD, 2004	
Metcalfa pruinosa (Say) [Hemiptera: Flatidae]	Citrus planthopper	Zangheri & Donadini, 1980		**Yes**
Myzus persicae (Sulzer) [Hemiptera: Aphididae]	Potato aphid	AAN, 1998	APPD, 2004	
Neoaliturus tenellus (Baker) [Hemiptera: Cicadellidae]	Beet leafhopper	EPPO, 2004		**Yes**
Nezara viridula (Linnaeus) [Hemiptera: Pentatomidae]	Green vegetable bug	EPPO, 2004	APPD, 2004	
Orthezia insignis Browne [Hemiptera: Ortheziidae]	Lantana bug	CABI, 2004		**Yes**
Parabemisia myricae (Kuwana) [Hemiptera: Aleyrodidae]	Bayberry whitefly	CABI, 2004	Restricted distribution (QDPI, 2002)	**Yes**
Parasaissetia nigra (Nietner) [Hemiptera: Coccidae]	Nigra scale	EPPO, 2004 (absent & formerly present)	AICN, 2004	
Parlatoria pergandii Comstock [Hemiptera: Diaspididae]	Chaff scale	AAN, 1998	AICN, 2004 (except WA)	**Yes**
Parlatoria ziziphi (Lucas) [Hemiptera: Diaspididae]	Black parlatoria scale	AAN, 1998		**Yes**

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Parthenolecanium corni (Bouché) [Hemiptera: Coccidae]	European fruit scale	EPPO, 2004	AICN, 2004 (except WA)	**Yes**
Parthenolecanium persicae (Fabricius) [Hemiptera: Coccidae]	Peach scale	CABI, 2004	APPD, 2004	
Phenacoccus madeirensis Green [Hemiptera: Pseudococcidae]	Madeira mealybug	CABI/EPPO, 2000		**Yes**
Planococcus citri (Risso) [Hemiptera: Pseudococccidae]	Citrus mealybug	AAN, 1998	APPD, 2004	
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococccidae]	Citrophilus mealybug	AAN, 1998	AICN, 2004 (except WA)	**Yes**
Pseudococcus longispinus Targioni-Tozzetti [Hemiptera: Pseudococccidae]	Long-tailed mealybug	AAN, 1998	APPD, 2004	
Pterochloroides persicae (Cholodkovsky) [Hemiptera: Aphididae]	Brown peach aphid	EPPO, 2004		**Yes**
Pulvinaria floccifera Westwood [Hemiptera: Coccidae]	Cushion scale	CABI, 2004	AICN, 2004 (except WA)	**Yes**
Rhopalosiphum maidis (Fitch) [Hemiptera: Aphididae]	Corn aphid	AAN, 1998	APPD, 2004	
Saissetia coffeae (Walker) [Hemiptera: Coccidae]	Brown coffee scale	Longo & Russo, 1986	APPD, 2004	
Saissetia oleae (Olivier) [Hemiptera: Coccidae]	Mediterranean black scale	Longo & Russo, 1986	APPD, 2004	
*Toxoptera aurantii (*Boyer De Fonscolombe) [Hemiptera: Aphididae]	Black citrus aphid	AAN, 1998	AICN, 2004; Berlandier, 1997	
Trialeurodes vaporariorum (Westwood) [Hemiptera: Aleyrodidae]	Greenhouse whitefly	Barbagallo *et al*., 1986	APPD, 2004	
***Trioza alacri**s* Flor [Hemiptera: Triozidae]	Laurel psyllid	Sampo, 1977		**Yes**
Unaspis yanonensis (Kuwana) [Hemiptera: Diaspididae]	Arrowhead scale	Vacante & Gerson, 1987		**Yes**
Hymenoptera (ants, wasps)				
Ageniaspis citricola Logvinovskaya [Hymenoptera: Encyrtidae]	Citrus leafminer parasite	AAN, 1998	AICN, 2004; Woods, 2005	
Aphanogmus steinitzi Priesner [Hymenoptera: Ceraphronidae]	Wasp	Sinacori *et al*., 1992		**Yes**
Aphytis chilensis Howard [Hymenoptera: Aphelinidae]	Parasitic wasp	Liotta, 1975	Waterhouse & Sands, 2001 (except WA)	**Yes**
Aphytis melinus DeBach [Hymenoptera: Aphelinidae]	Red scale parasite	AAN, 1998	AICN, 2004; Anon, 1981	

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Cales noacki Howard [Hymenoptera: Aphelinidae]	Parasitic wasp	AAN, 1998	CABI, 2004 (except WA)	**Yes**
Camponotus nylanderi Emery [Hymenoptera: Formicidae]	Black ant	Tumminelli *et al*., 1997		**Yes**
Encarsia formosa Gahan [Hymenoptera: Aphelinidae]	Parasitic wasp	CABI, 2004	AICN, 2004	
Leptomastix dactilopii Howard [Hymenoptera: Encyrtidae]	Mealybug parasite	Mineo & Viggiani, 1976	AICN, 2004 (except WA)	**Yes**
Linepithema humile (Mayr) [Hymenoptera: Formicidae]	Argentine ant	AAN, 1998	APPD, 2004	
Lysiphlebus testaceipe**s** (Cresson) [Hymenoptera: Aphidiinae]	Parasitic wasp	Melia, 1993	Stary & Carver, 1979 (except WA)	**Yes**
Tapinoma erraticum (Latreille) [Hymenoptera: Formicidae]	Black ant	Tumminelli *et al*., 1997		**Yes**
Tapinoma nigerrimum (Nylander) [Hymenoptera: Formicidae]	Black ant	AAN, 1998		**Yes**
Lepidoptera (moths, butterflies)				
Agrotis ipsilon (Hufnagel) [Lepidoptera: Noctuidae]	Black cutworm	CABI, 2004	AICN, 2004	
Apomyelois ceratoniae Zeller [Lepidoptera: Pyralidae]	Locust bean moth	AAN, 1998	ICDB, 2002	
Archips rosanus Linnaeus [Lepidoptera: Tortricidae]	Rose tortrix moth	AAN, 1998		**Yes**
Cacoecimorpha pronubana Hübner [Lepidoptera: Tortricidae]	Mediterranean carnation tortrix	Mineo, 1986		**Yes**
Cadra cautella Walker [Lepidoptera: Pyralidae]	Tropical warehouse moth	Mineo, 1986	AICN, 2004	
Charaxes jasius (Linnaeus) [Lepidoptera: Nymphalidae]	Butterfly	Longo, 1992		**Yes**
Cryptoblabes gnidiella (Millière) [Lepidoptera: Pyralidae]	Citrus pyralid	Mineo, 1986		**Yes**
Gymnoscelis rufifasciata (Haworth) [Lepidoptera: Geometridae]		Mineo, 1986		**Yes**
Helicoverpa armigera (Hübner) [Lepidoptera: Noctuidae]	Cotton bollworm	EPPO, 2004	AICN, 2004	
Hyphantria cunea Drury [Lepidoptera: Arctiidae]	Fall web-worm	EPPO, 2004		**Yes**
Peridroma saucia (Hübner) [Lepidoptera: Noctuidae]	Variegated cutworm	CABI, 2004		**Yes**
Phyllocnistis citrella Stainton [Lepidoptera: Gracillariidae]	Asian leaf miner	AAN, 1998	Wilson, 1991	
Prays citri Millière [Lepidoptera: Yponomeutidae]	Citrus flower moth	AAN, 1998		**Yes**
Spodoptera exigua (Hübner) [Lepidoptera: Noctuidae]	Beet armyworm	CABI, 2004	AICN, 2004; ICDB, 2002	

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Spodoptera littoralis (Boisduval) [Lepidoptera: Noctuidae]	Mediterranean climbing cutworm	EPPO, 2004		**Yes**
Trichoplusia ni (Hübner) [Lepidoptera: Noctuidae]	Cabbage looper	CABI, 2004		**Yes**
Xestia c-nigrum (Linnaeus) [Lepidoptera: Noctuidae]	Spotted cutworm	CABI, 2004		**Yes**
Neuroptera (lacewings)				
Anisochrysa venusta [Neuroptera: Chrysopidae]	Lacewing	Pantaleoni & Lepera, 1985		**Yes**
Chrysopa carnea Stephens [Neuroptera: Chrysopidae]	Green lacewing	Pantaleoni & Lepera, 1985	Readshaw, 1975 (except WA)	**Yes**
Conwentzia psociformis (Curtis) [Neuroptera: Coniopterygidae]	Lacewing	Sinacori *et al*., 1992		**Yes**
Thysanoptera (thrips)				
Aeolothrips ericae Bagnall [Thysanoptera: Thripidae]	Predatory thrips	Conti *et al*., 2002		**Yes**
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips	Marullo, 2002	Mound & Gillespie, 1997[10]	**Yes**
Heliothrips haemorrhoidalis (Bouché) [Thysanoptera: Thripidae]	Greenhouse thrips	AAN, 1998	AICN, 2004	
Limothrips cerealium (Haliday) [Thysanoptera: Thripidae]	Grain thrips	CABI, 2004	AICN, 2004	
Pezothrips kellyanus Bagnall [Thysanoptera: Thripidae]	Kelly's citrus thrip	Conti *et al*., 2002	Broughton & De Lima, 2002	
Pseudodendrothrips mori [Thysanoptera: Dendrothripidae]	Mulberry thrips	Cappellozza & Miotto, 1975	Mound, 2004	
Thrips alni Uzel [Thysanoptera: Thripidae]	Flower thrips	Longo, 1986		**Yes**
Thrips flavus Shrank [Thysanoptera: Thripidae]	Flower thrips	Conti *et al*., 2002		**Yes**
Thrips tabaci Lindeman [Thysanoptera: Thripidae]	Onion thrips	Conti *et al*., 2002	AICN, 2004	
Thrips urticae Fabr. [Thysanoptera: Thripidae]	Flower thrips	Longo, 1986		**Yes**
PREDATORY MITES				
Acari (mites)				
Amblydromella rhenanoides (Athias-Henriot) [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**

10 Under official control in Tasmania and the Northern Territory.

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Amblyseius aberrans (Oudemans) [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Amblyseius barkeri (Hughes) [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Amblyseius degenerans (Berlese) [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Amblyseius italicus Chant [Acari: Phytoseiidae]	Phytoseiid mite	Vacante *et al*., 1988		**Yes**
Amblyseius largoensis (Muma) [Acari: Phytoseiidae]	Phytoseiid mite	AAN, 1998	Halliday, 1998	[11]
Amblyseius messor (Weinstein) [Acari: Phytoseiidae]	Phytoseiid mite	AAN, 1998		[12]
Amblyseius potentillae (Garman) [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Amblyseius stipulatus Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Amblyseius swirskii Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Anystis baccarum Linnaeus [Acari: Anystidae]	Whirlygig mite	Vacante *et al*., 1988	Holm & Wallace, 1989; ICDB, 2002	
Calvolia hebeclinii Sicher [Acari: Saproglyphidae]	Stigmaeid mite	Vacante & Nucifora, 1986a		**Yes**
Cheletogenes ornatus (Canestrini & Fanzago) [Acari: Cheyletidae]	Cheyletid mite	Vacante & Nucifora, 1986a		**Yes**
Cheletomimus berlesei (Oudemans) [Acari: Cheyletidae]	Cheyletid mite	Vacante & Nucifora, 1986a		**Yes**
Cheletomimus minutes (Oudemans) [Acari: Cheyletidae]	Cheyletid mite	Vacante & Nucifora, 1986a		**Yes**
Cunaxa capreolus Berlese [Acari: Cunaxidae]	Cunaxid mite	Vacante & Nucifora, 1986a		**Yes**
Cunaxa setirostris (Hermann) [Acari: Cunaxidae]	Cunaxid mite	Vacante & Nucifora, 1986a		**Yes**
Cunaxoides oliveri Schruft [Acari: Cunaxidae]	Cunaxid mite	Vacante *et al*., 1988		**Yes**
Eryngiopus bifidus Wood [Acari: Stigmaeidae]	Stigmaeid mite	Vacante & Gerson, 1987		**Yes**
Eryngiopus siculus Vacante & Gerson [Acari: Stigmaeidae]	Stigmaeid mite	Vacante & Gerson, 1987		**Yes**
Eutogenes citri Gerson [Acari: Cheyletidae]	Cheyletid mite	Vacante & Nucifora, 1986a		**Yes**
Hemisarcoptes malus (Shimer) [Acari: Hemisarcoptidae]	Hemisacopid mite	Vacante & Nucifora, 1986a		**Yes**
Ledermuelleriopsis plumosus Willmann [Acari: Stigmaeidae]	Stigmaeid mite	Vacante & Nucifora, 1986a		**Yes**

11 This species was reported previously in Italy. However, it was not found in the surveys conducted in 1986 (Vacante & Nucifora, 1986a). On the basis of this information this mite was not considered further.

12 This species was reported previously in Sicily on lemon. However, it was not found in the surveys conducted in 1986 (Vacante & Nucifora, 1986a). On the basis of this information this mite was not considered further.

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Mediolata similans Willmann [Acari: Stigmaeidae]	Stigmaeid mite	Vacante *et al*., 1988		**Yes**
Neoseiulus californicus McGregor [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Phytoseiulus finitimus Ribaga [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Phytoseiulus panormita Ragusa & Swirski [Acari: Phytoseiidae]	Phytoseiid mite	Vacante *et al*., 1988		**Yes**
Phytoseiulus persimilis Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a	Graham & Gatter, 1990	
Proctolaelaps pygmaeus (Muller) [Acari: Ascidae]	Ascid mite	Vacante & Nucifora, 1986a	Halliday *et al*., 2004	
Seiulus amaliae Ragusa & Swirski [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Seiulus finlandicus (Oudemans) [Acari: Phytoseiidae]	Phytoseiid mite	Vacante *et al*., 1988		**Yes**
Typhlodromus athenas Porath & Swirski [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Typhlodromus cryptus (Oudemans) [Acari: Phytoseiidae]	Phytoseiid mite	Vacante & Nucifora, 1986a		**Yes**
Typhlodromus exhilaratus Ragusa [Acari: Phytoseiidae]	Phytoseiid mite	Ragusa, 1981		**Yes**
Typhlodromus phialatus Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite	Vacante *et al*., 1988		**Yes**
Typhlodromus talbii Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite	Vacante *et al*., 1988		**Yes**
Zetzellia collyerae (Gonzalez-Rodriguez) [Acari: Stigmaeidae]	Stigmaeid mite	Vacante & Nucifora, 1986a	Readshaw, 1975 (except WA)	**Yes**
Zetzellia graeciana Gonzales [Acari: Stigmaeidae]	Stigmaeid mite	Vacante & Nucifora, 1986a		**Yes**
Zetzellia mali (Ewing) [Acari: Stigmaeidae]	Stigmaeid mite	Vacante & Nucifora, 1986a		**Yes**
GASTROPODS				
Deroceras reticulatum O.F. Muller [Gastropoda: Limacidae]	Slug	CABI, 2004	Young, 1996	
Helix aspersa Muller [Gastropoda: Helicidae]	Brown garden snail	Dogan, 1983	Davis *et al*., 1997	
Theba pisana [Gastropoda: Helicidae]	White garden snail	EPPO, 2004	Buckland *et al*., 1990	
PATHOGENS				
Bacteria				
Pseudomonas syringae van Hall pv. *syringae* van Hall	Bacterial blast	AAN, 1998	APPD, 2004	
Pseudomonas viridiflava (Burkholder) Dowson	Bacterial blight	CABI, 2004	Bradbury, 1986	
Rhizobium radiobacter (Beijerinck & van Delden) Young *et al*.	Crown gall	CABI, 2004	APPD, 2004	
Xanthomonas campestris pv. *campestris* (Pammel) Dowson	Black rot	CABI, 2004	APPD, 2004	

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Fungi				
Alternaria alternata (Fr.: Fr.) Keissl.	Alternaria leaf blight	CABI, 2004	APPD, 2004	
Alternaria brassicae (Berk.) Sacc.	Alternaria blight	CABI, 2004	APPD, 2004	
Alternaria citri Ellis & N. Pierce	Core rot of citrus	AAN, 1998	APPD, 2004	
Armillaria mellea (Vahl) P. Kummer	Armillaria root rot	AAN, 1998		**Yes**
Armillaria tabescens (Scop.) Dennis *et al*.	Armillaria root rot	CABI, 2004		**Yes**
Ascochyta hesperidearum Penz. in Sacc.	Leaf spot	Mel'nik *et al.* 2000		**Yes**
Aspergillus niger Tiegh.	Aspergillus rot	CABI, 2004	APPD, 2004	
Athelia rolfsii (Curzi) C.C. Tu & Kimbrough	Seedling blight	CABI, 2004	APPD, 2004	
Botryosphaeria obtuse (Schwein.) Shoemaker	Black rot	CABI, 2004	APPD, 2004	
Botryosphaeria ribis Grossenbacher & Duggar	Stem end rot	AAN, 1998	Shivas, 1989	
Botrytis cinerea Pers: Fr.	Grey mould	AAN, 1998	APPD, 2004	
Capnodium citri Mont.	Sooty mould	AAN, 1998		**Yes**
Ceratocystis fimbriata Ellis & Halst.	Ceratocystis blight	EPPO, 2004	Walker *et al*., 1988	
Cercospora penzigii Sacc.	Leaf spot	Farr *et al*., 1989		**Yes**
Cochliobolus lunatus R.R. Nelson & Haasis	Black leaf spot	CABI, 2004	APPD, 2004	
Colletotrichum acutatum Simmonds ex Simmonds	Anthracnose	EPPO, 2004[13]	APPD, 2004[14]	
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. In Penz.	Anthracnose	AAN, 1998	APPD, 2004	
Diaporthe citri F.A. Wolf	Gummosis; Melanose	EPPO, 2004	APPD, 2004	
Elsinoe australis Bitanc. & Jenkins	Sweet orange scab	Ciccarone, 1957; EPPO, 2004[15]	APPD, 2004 (certain strains)	
Eutypa lata (Per.: Fr.) L.R. Tulasne & C. Tulasne	Eutypa dieback	CABI, 2004	APPD, 2004, Shivas, 1989	
Fusarium lateritium Nees: Fr.	Dieback	AAN, 1998	APPD, 2004	
Fusarium solani (Martin) Sacc.	Dry root rot	AAN, 1998	APPD, 2004	

13 Strain of *Colletotrichum acutatum* causing postbloom fruit drop (PFD), is endemic in the humid tropics of the Americas only (Peres *et al*., 2002). PFD strain does not cause anthracnose.

14 There is only one record of *Colletotrichum acutatum* on citrus in Australia (APPD, 2004). The strain responsible for postbloom fruit drop is not present in Australia.

15 Ciccarone (1957) identified a scab on lemon fruits in Sicily as caused by *E. australis* but there have been no further records in Italy. EPPO (2004) lists the current status of *E. australis* as absent in Italy. Therefore, this pathogen is not considered further.

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Geotrichum candidum Link	Sour rot	CABI, 2004	APPD, 2004	
Lasiodiplodia theobromae (Pat.) Griffiths & Maubl.	Stem-end rot	CABI, 2004	APPD, 2004	
Macrophomina phaseolina (Tassi) Goidanich	Charcoal root rot	CABI, 2004	APPD, 2004	
Nematospora coryli Peglion	Dry rot of citrus	EPPO, 2004	Shivas *et al*, 2005 (except WA)	**Yes**
Penicillium digitatum (Pers.: Fr) Sacc.	Green mould	AAN, 1998	Shivas, 1989	
Penicillium italicum Wehmer	Blue mould	AAN, 1998	Shivas, 1989	
Phoma tracheiphila (Petri) Kantachveli & Gikachvili	Mal secco	AAN, 1998[16]		**Yes**
Phytophthora cactorum (Lebert & Cohn) Schröter	Seedling damping-off	AAN, 1998	APPD, 2004	
Phytophthora citricola Saw.	Root rot	AAN, 1998	Shivas, 1989	
Phytophthora citrophthora (R.H. Sm. & E. Sm.) Leonian	Foot rot of Citrus	AAN, 1998	APPD, 2004	
Phytophthora cryptogea Pethybridge & Lafferty	Damping off	EPPO, 2004	APPD, 2004	
Phytophthora hibernalis Carne	Root rot	AAN, 1998	Shivas, 1989	
Phytophthora nicotianae Breda de Haan	Root rot	AAN, 1998	APPD, 2004	
Phytophthora palmivora (E. J. Butler) E. J. Butler	Brown rot of fruit	CABI, 2004	APPD, 2004 (except WA)	**Yes**
Phytophthora parasitica Dastur	Root rot	CABI, 2004	APPD, 2004	
Phytophthora syringa*e* Kleb.	Brown rot	AAN, 1998	APPD, 2004 (except WA)	**Yes**
Pythium debaryanum Hesse	Damping off	CABI, 2004	APPD, 2004	
Pythium splendens H. Braun	Root rot	CABI, 2004	APPD, 2004	
Pythium vexans de Bary	Damping off	CABI, 2004	APPD, 2004	
Rosellinia necatrix Prill	Dematophora root rot	CABI, 2004	APPD, 2004	
Sclerotinia sclerotiorum (Lib.) De Bary	Collar rot	AAN, 1998	APPD, 2004	
Septoria citri Pass.	Septoria spot	AAN, 1998	APPD, 2004 (except WA)	**Yes**
Thielaviopsis basicola (Berk. & Broome) Ferraris	Black root rot	CABI, 2004	APPD, 2004	
Nematodes				
Crossonema multisquamatum (Kirjanova) Mehta & Raski		AAN, 1998		**Yes**

16 Italy is known to have Mal secco. However, under Italian domestic legislation it is obligatory to destroy lemon trees and other susceptible plants affected by *Phoma tracheiphila* (AAN, 1998).

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Helicotylenchus multicinctus (Cobb) Golden	Spiral nematode	CABI, 2004	McLeod *et al*., 1994	
Meloidogyne incognita (Kofoid & White) Chitwood	Root-knot nematode	CABI, 2004	McLeod *et al*., 1994	
Meloidogyne javanica (Treub) Chitwood	Root-knot nematode	CABI, 2004	McLeod *et al*., 1994	
Pratylenchus coffeae (Zimmermann) Filipjev & Schuurmans Steckhoven	Root lesion nematode	CABI, 2004	McLeod *et al*., 1994	
Pratylenchus penetrans (Cobb) Filipjev & Schuurmans Stekhoven	Root lesion nematode	CABI, 2004	McLeod *et al*., 1994	
Pratylenchus vulnus Allen & Jensen	Root lesion nematode	AAN, 1998	McLeod *et al*., 1994	
Radopholus similis (Cobb) Thorne	Burrowing nematode	CABI, 2004	McLeod *et al*., 1994	
Rotylenchulus macrodoratus Dasgupta *et al*.	A reniform nematode	AAN, 1998		**Yes**
Tylenchulus semipenetrans Cobb	Root nematode	AAN, 1998	McLeod *et al*., 1994	
Xiphinema index Thorne & Allen	Dagger nematode	CABI, 2004	McLeod *et al*., 1994 (except WA)	**Yes**
Phytoplasma				
Spiroplasma citri Saglio *et al*.	Stubborn disease of citrus	EPPO, 2004		**Yes**
Viroids				
Citrus exocortis viroid	Citrus exocortis	AAN, 1998	Fraser & Broadbent, 1979 (except WA)	**Yes**
Citrus xyloporosis viroid	Citrus cachexia	AAN, 1998	Fraser & Broadbent, 1979 (except WA)	**Yes**
Citrus viroid III	Citrus viroid	Malfitano *et al*., 2005		**Yes**
Citrus viroid IV	Citrus viroid	Malfitano *et al*., 2005		**Yes**
Citrus bent leaf viroid	Citrus viroid	Malfitano *et al*., 2005		**Yes**
Viruses				
Citrus impietratura virus	Citrus impietratura disease	CABI, 2004		**Yes**

Pest	Common name	Presence in		Consider further (yes/no)
		Italy	Australia	
Citrus ring spot virus	Psorosis complex	AAN, 1998	Fraser & Broadbent, 1979 (except WA)	**Yes**
Citrus tristeza *closterovirus*	Lime die-back	Davino & Rosa, 1986[17]	Fraser & Broadbent, 1979[18]	
Citrus variegation virus	Variegation disease	AAN, 1998	Buchen-Osmond, 1988 (except WA)	**Yes**

17 CTV was first reported in Italy in 1955 (Russo, 1956) and was found in a restricted area of Calabria district (Davino *et al*., 1984). Subsequent surveys of the main citrus growing areas found around 100 CTV-infected trees which were removed (Davino *et al*., 1986). After five year survey it appears the disease did not spread from the orchard where it was found for the first time in Calabria (Davino *et al*., 1988). CTV has been eradicated from Italy (ANN, 1998). Under Italian legislation it is obligatory to destroy plants infected with CTV (AAN, 1998).

18 A stem pitting strain that only affects limes, grapefruit and sweet orange exists (Timmer *et al*., 2000). A strain that affects sweet orange is presented in a restricted area of Queensland and there are intra and interstate restrictions on the movement of budwood.

Appendix – 1b: Pest Categorisation for Sweet Oranges from Italy – Pathway Association

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
ARTHROPODS				
Acari (mites)				
Aculops pelekassi (Keifer) [Acari: Eriophyidae]	Pink citrus rust mite	Yes	Feeds on green stems, leaves and fruit (Benfatto, 1980).	**Yes**
Bryobia tunisiae Manson [Acari: Tetranychidae]		No	Has been found on lemon leaves in Sicily (Vacante & Nucifora, 1986a). A polyphagous species that feeds on herbaceous plants beneath the canopy. This mite is rarely found on citrus and does not cause any damage (Vacante & Nucifora, 1986a).	
Eupelops acromios (Hermann) [Acari: Phenopelopidae]	Oribatid mite	No	This genus of mites is associated with fungi (O'Connell & Bolger, 1997) and leaf litter (Hagvar & Kjondal, 1981).	
Fungitarsonemus monasterii Lombardini [Acari: Tarsonemidae]	Tarsonemid mite	No	Other species of this genus are known biocontrol agents commonly used in fruit orchards.	
Humerobates rostrolamellatus Grandjean [Acari: Ceratozetidae]	Oribatid mite	No	Recorded as living on bark (Lebrun *et al.*, 1978). Mites of the family Ceratozetidae are principally saprophagous or fungivorous and are found in litter (Smith *et al.*, 1998).	
Lorryia australensis (Baker) [Acari: Tydeidae]	Yellow citrus mite	No	Feeding habits are unknown and associated with orange leaves in Italy (Vacante & Nucifora, 1986a).	
Lorryia ferula Baker [Acari: Tydeidae]	Tydeid mite	Yes	This species have been found on the leaves and fruit of lemon, orange, mandarin and Clementine in Sicily (Vacante & Nucifora, 1986a).	**Yes**
Lorryia formosa Cooreman [Acari: Tydeidae]	Yellow mite	Yes	Present on leaves along the mid-rib (Badii *et al.*, 2001), feeding on scale excreted honeydew and sooty mold (Mendel & Gerson, 1982). Associated with fruit (Jeppson *et al*., 1975).	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Lorryia reticulata (Oudemans) [Acari: Tydeidae]	Reticulate mite	No	Feeding habits are unknown and associated with orange leaves in Italy (Vacante & Nucifora, 1986a).	
Lorryia teresae (Carmona) [Acari: Tydeidae]	Tydeid mite	No	Feeding habits are unknown and associated with orange leaves in Italy (Vacante & Nucifora, 1986a).	
Metalorryia magdalenae (Baker) [Acari: Tydeidae]	Tydeid mite	No	Tydeid mites are found in mosses, lichens and plant leaves where they feed on fungi or prey on small insects, and mites and their eggs (Baker & Wharton, 1952).	
Micreremus gracilior Willmann [Acari: Micremidae]	Oribatid mite	No	Mites of this genus feed on mosses, lichens and fungi found on the leaves and branches of fruit trees (Karg, 1971).	
Orthotydeus caudatus (Dugès) [Acari: Tydeidae]	Tydeid mite	No	Feeding habits are unknown and associated with orange leaves in Italy (Vacante & Nucifora, 1986a).	
Orthotydeus foliorum (Schrank) [Acari: Tydeidae]	Tydeid mite	No	Feeding habits are unknown and associated with orange leaves in Italy (Vacante & Nucifora, 1986a).	
Orthotydeus kochi Oudemans [Acari: Tydeidae]	Tydeid mite	No	Feeding habits are unknown and associated with orange leaves in Italy (Vacante & Nucifora, 1986a).	
Panonychus citri McGregor [Acari: Tetranychidae]	Citrus red mite	Yes	Feeds on foliage and fruits (Smith *et. al.*, 1997).	**Yes**
Petrobia tunisiae Manson [Acari: Tetranychidae]	Spider mite	No	A polyphagous species from herbaceous plants beneath the canopy. Rarely found on citrus and causes no damage. Recovered only from lemon leaves in Italy (Vacante & Nucifora, 1986a).	
Phauloppia lucorum C.L. Koch [Acari: Oribatulidae]	Oribatulid mite	No	These mites live in the soil and eat fungi, algae and dead plant material. Associated with moss and lichen (Smrz, 1992; Froberg *et.al.*, 2003)	
Pronematus ubiquitus (McGregor) [Acari: Tydeidae]	Tydeid mite	Yes	Tydeid mites are generally scavengers, feeding on debris on the surface of citrus leaves and fruit. Natural enemy of *Brevipalpus californicus* and *Tetranychus urticae* (CABI, 2004).	**Yes**
Siculobata sicula Berlese [Acari: Oribatulidae]	Oribatulid mite	No	A mycophagous or saprophagous mite (Vacante & Nucifora, 1986a).	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Tarsonemus aurantii Oudemans [Acari: Tarsonemidae]	Tarsonemid mite	Yes	A mycophagous mite recorded from leaves and fruit of lemon and orange (Vacante & Nucifora, 1986a).	**Yes**
Tarsonemus bilobatus Suski [Acari: Tarsonemidae]	Tarsonemid mite	Yes	Present sporadically on orange fruit and leaves, with sooty mould (Nucifora & Vacante, 2004). Most mites of this genus are mycophagous.	**Yes**
Tarsonemus confusus Ewing [Acari: Tarsonemidae]	Tarsonemid mite	No	Found on the bark of lemon and orange trees (Nucifera & Vacante, 2004).	
Tarsonemus floricolus Canestrini & Fanzago [Acari: Tarsonemidae]	Tarsonemid mite	Yes	Present sporadically on orange fruit and leaves, with sooty mould (Nucifora & Vacante, 2004). Most mites of this genus are mycophagous.	**Yes**
Tarsonemus idaeus Suski [Acari: Tarsonemidae]	Tarsonemid mite	Yes	Present on leaves and fruit of orange and lemon with sooty mould (Nucifora & Vacante, 2004). This mite develops either on fungi or on yeast (Suski, 1968), and is known as a fungivorous species (Korah & Osman, 1978).	**Yes**
Tarsonemus lobosus Suski [Acari: Tarsonemidae]	Tarsonemid mite	No	Occasionally present on bark crevices of the trunk and large branches of oranges and lemon trees (Nucifora & Vacante, 2004).	
Tarsonemus parawaitei Kim *et al*. [Acari: Tarsonemidae]	Tarsonemid mite	No	Adults of tarsonemid mite are mainly found on insects, plants and litter. Adults are parasitoids, predaceous and phytophagous.	
Tarsonemus smithi Ewing [Acari: Tarsonemidae]	Tarsonemid mite	No	A mycophagous species sporadically present on leaves of orange and lemon in Sicily (Vacante & Nucifora, 1986a).	
Tarsonemus unguis Ewing & Ewing [Acari: Tarsonemidae]	Tarsonemid mite	No	A species sporadically found on lemon leaves in Sicily (Vacante & Nucifora, 1986a).	
Tarsonemus waitei Banks [Acari: Tarsonemidae]	Tarsonemid mite	No	A mycophagous species present on leaves of orange and lemon in Sicily (Vacante & Nucifora, 1986a).	
Tetranychina harti (Ewing) [Acari: Tetranychidae]	Spider mite	No	Overwinters on the trunk and branches of citrus (Ciampolini *et al.*, 1985).	
Thyreophagus cooremani Fain [Acari: Acaridae]	Acarid mite	No	*Thyreophagus* spp. are associated with woody substrates, decaying matter and fungi (O'Conner, 2001).	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Thyreophagus corticalis (Michael) [Acari: Acaridae]	Acarid mite	No	*Thyreophagus* spp. are associated with woody substrates, decaying matter and fungi (O'Conner, 2001).	
Thyreophagus entomophagus italicus Vacante [Acari: Acaridae]	Acarid mite	No	*Thyreophagus* spp. are associated with woody substrates, decaying matter and fungi (O'Conner, 2001).	
Thyreophagus gallegoi Portus & Gomez [Acari: Acaridae]	Acarid mite	No	*Thyreophagus* spp. are associated with woody substrates, decaying matter and fungi (O'Conner, 2001).	
Trichoribates angustatus Mihelcic [Acari: Ceratozetidae]	Mite	No	Present on twigs of lemon and orange in Sicily (Vacante & Nucifora, 1986a). Probably mycophagous.	
Triophtydeus triophthalmus (Oudemans) [Acari: Tydeidae]	Tydeid mite	No	Natural enemy of *Coleophora serratella* (CABI, 2004).	
Tyrophagus neiswanderi Johnson & Bruce [Acari: Phytoseiidae]	Acarid mite	No	*Tyrophagus* spp. are associated with dried organic substances (Russell, 2001). Other species of this genus live on all sorts of organic substances, bulbs and plant debris. These mites are scavengers, feeding on fungi, bacteria and decaying leaf material.	
Tyrophagus palmarum (Oudemans) [Acari: Phytoseiidae]	Acarid mite	No	*Tyrophagus* spp. are associated with dried organic substances (Russell, 2001). Other species of this genus live on all sorts of organic substances, bulbs and plant debris. These mites are scavengers, feeding on fungi, bacteria and decaying leaf material.	
Tyrophagus tropicus Robertson [Acari: Phytoseiidae]	Acarid mite	No	*Tyrophagus spp.* are associated with dried organic substances (Russell, 2001). Other species of this genus live on all sorts of organic substances, bulbs and plant debris. These mites are scavengers, feeding on fungi, bacteria and decaying leaf material.	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Coleoptera (beetle, weevils)				
Anoplophora chinensis (Foster) [Coleoptera: Cerambycidae]	White-spotted longicorn beetle	No	Polyphagous on living wood (Kojima & Nakamura, 1986). Larvae bore into the stems (Mitomi *et al*., 1990) and adults feed on foliage and bark of the tree (Kajiwara *et al*., 1986). The flight potential of adults results in natural dispersal (Adachi, 1990). In international trade, species of *Anoplophora* are most likely to be moved as eggs, larvae or pupae in woody planting material.	
Apate monachus Fabricius [Coleoptera: Bostrichidae]	Black borer	No	Polyphagous and a wood-boring beetle. Completes its life cycle on a wide range of African trees and host crops. Adults bore deeply into the wood of living host trees while feeding. Females excavate galleries in dead wood, in which eggs are also laid. Larvae live in dead trees, excavating their own tunnels deep in the wood (Chararas & Balachowsky, 1962).	
Aphtona nigriceps Redtb [Coleoptera: Chrysomelidae]	Chrysomelid beetle	No	Feeds on citrus flowers (Benfatto & Longo, 1986).	
Cetonia arurata Linnaeus [Coleoptera: Scarabeidae]	Flower weevil	No	Adults of this species have been recorded feeding on flowers, leaves and twigs (Benfatto & Longo, 1986).	
Coccinella septempunctata Linnaeus [Coleoptera: Coccinellidae]	Seven-spotted ladybird	No	Primarily feeds on aphids, however, ladybird larvae and adults may supplement their normal prey in times of scarcity of other types of food (Frank & Mizell, 2004). It is widely used for control against aphids on cotton in China, on brassica crops in Pakistan, and in apple orchards in Hungary, Poland, Belgium and Canada.	
Crepidptera impressa Fabricius [Coleoptera: Chrysomelidae]	Chrysomelid beetle	No	Feeds on citrus flowers (Benfatto & Longo, 1986).	
Crepidptera ventralis [Coleoptera: Chrysomelidae]	Chrysomelid beetle	No	Feeds on citrus flowers (Benfatto & Longo, 1986).	
Epitrix hirtipennis (Melsheimer) Coleoptera: Chrysomelidae]	Tobacco flea beetle	No	The tobacco flea beetle is a pest of tobacco, tomato, and potato and will also attack jimsonweed, ground cherry and occasionally has been found on citrus. Eggs are laid on the soil surface beneath the plants. Eggs hatch in about a week and larvae feed on, and tunnel in, the roots and stems. Adults feed on leaves causing small round “shot-holes” (Roberts & Guillebeau, 2000).	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Longitarsus brunneus Duft [Coleoptera: Chrysomelidae]	Chrysomelid beetle	No	Feeds on citrus flowers (Benfatto & Longo, 1986).	
Longitarsus tabidus Fabricius [Coleoptera: Chrysomelidae]	Chrysomelid beetle	No	Feed on flowers of citrus trees (Benfatto & Longo, 1986).	
Otiorhynchus armatus Bodenheimer [Coleoptera: Curculionidae]	Curculio weevil	No	Larvae feed on the roots and adults feed on leaves (Benfatto & Longo, 1986).	
Otiorhynchus rhacusensis Germ. [Coleoptera: Curculionidae]	Curculio weevil	No	Larvae feed on the roots and adults feed on leaves (Benfatto & Longo, 1986).	
Oxythyrea funesta Poda [Coleoptera: Scarabeidae]	Scarabeid weevil	No	Adults of this species have been recorded feeding on flowers, leaves and twigs (Benfatto & Longo, 1986).	
Pentodon punctatus Vill [Coleoptera: Scarabeidae]	Scarabeid weevil	No	Adults of this species have been recorded feeding on flowers, leaves and twigs (Benfatto & Longo, 1986).	
Rhizotrogus rugifrons Burmeister [Coleoptera: Scarabaeidae]	Scarab beetle	No	*Rhizotrogus* beetles are scarabs belonging to the subfamily Melolonthinae (chafers). Larvae feed on roots and decaying matter, while adults are leaf feeders (Lawrence & Britton, 1991).	
Stethorus punctillum (Weise) [Coleoptera: Coccinellidae]	Mite eating ladybird	No	Lady beetles are among the most beneficial insects. Mite eating ladybird is a common species. It feeds on *Aculus schlechtendali*, *Bryobia rubrioculus*, *Eotetranychus pruni*, *Panonychus ulmi*, *Phytoseiulus persimilis*, *Tetranychus cinnabarinus* and *Tetranychus truncatus* (CABI, 2004).	
Synoxylon sexdentatum Oliver [Coleoptera: Bostrichidae]	Bostrichid beetle	No	Adults feed on branches and twigs whereas larvae feed on dead wood (Benfatto & Longo, 1986).	
Trichoferus griseus Fabricius [Coleoptera: Cerambycidae]	Cerambycid beetle	No	Not associated with fruit pathway (Benfatto & Longo, 1986).	
Tropinota hirta Poda [Coleoptera: Scarabeidae]	Scarabeid weevil	No	Adults of this species have been recorded feeding on flowers (Benfatto & Longo, 1986).	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Tropinota squalida Scopoli [Coleoptera: Scarabeidae]	Scarabeid weevil	No	Adults of this species have been recorded feeding on flowers (Benfatto & Longo, 1986).	
Xylomedes coronata Mars [Coleoptera: Bostrichidae]	Bostrichid beetle	No	Adults feed on branches and twigs whereas larvae feed on dead wood (Benfatto & Longo, 1986).	
Diptera (flies)				
Ceratitis capitata (Wiedemann) Diptera: Tephritidae]	Mediterranean fruit fly; Medfly	Yes	Lays eggs in the fruit. Larvae feed and develop within the fruit. Mature larvae leave the fruit to pupate in the soil (Fletcher, 1989).	**Yes**
Syrphus spp. [Diptera: Syrphidae]	Hover fly	No	Natural enemy of *Diuraphis noxia* and *Metopolophium festucae* (CABI, 2004).	
Hemiptera (aphids, leafhoppers, mealybugs, psyllids, scales, true bugs, whiteflies)				
Aleurothrixus floccosus (Maskell) [Hemiptera: Aleyrodidae]	Woolly whitefly	Yes	Primarily feeds on leaves. Lives on the lower surfaces of young rolled leaves and lays eggs there and on fruit (Vulic & Beltran, 1977).	**Yes**
Aphis fabae Scopoli [Hemiptera: Aphididae]	Black bean aphid	No	Polyphagous foliage and blossom feeder (Beniecki, 2002).	
Asymmetrasca decedens (Paoli) [Hemiptera: Cicadellidae]	Green leafhopper	No	Leafhoppers are sapsuckers that feed on the leaves, twigs and branches of the host tree. Excretes copious amounts of honeydew on which sooty moulds grow. Eggs are usually laid in slits in the bark on branches or twigs. All nymphal and adult stages feed by sucking the sap of the host tree. Primarily feeds on the underside of leaves by sucking out the liquid cell contents.	
Bemisia tabaci biotype B (Gennadius) [Hemiptera: Aleyrodidae]	Tobacco whitefly	No	Eggs are laid and immature stages develop on the undersides of the leaves. Primarily feeds on leaves (Hamon, 2001). Adults congregate, feed and mate on the under surface of the leaves. Numbers can be large enough to create ’clouds’ when the insects are disturbed.	
Calocoris trivialis (Costa) [Hemiptera: Miridae]	Mirid bug	No	Mirid bugs are considered beneficial, being predators of pest mites and aphids. From bloom until shortly after petal fall, however, they may severely damage fruit by feeding on flower parts or young fruitlets (Kain & Kovach, 2001).	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Ceroplastes floridensis Comstock [Hemiptera: Coccidae]	Florida wax scale	No	Wax scales feed by extracting sap from the vascular system and a heavy infestation can rob the host of enough sap to cause premature leaf drop and branch dieback. Wax scales secrete large quantities of honeydew. Sooty mould grows on honeydew, rendering the plant and its surroundings unsightly (Stimmel, 1998).	
Ceroplastes japonicus Green [Hemiptera: Coccidae]	Japan wax scale	No	Wax scales feed by extracting sap from the vascular system and a heavy infestation cause premature leaf drop and branch dieback. Fertilized females overwinter on the tips of branches (Camporese & Pellizzari, 1998; Jiang & Gu, 1988). Growth of sooty moulds on honeydew produced by scales reduces the market value of plants and produce (Prokopenko & Mokrousova, 1981).	
Ceroplastes rusci (Linnaeus) [Hemiptera: Coccidae]	Fig tree scale	No	Fig tree scale feed by extracting sap from the vascular system and a heavy infestation can cause premature leaf drop and branch dieback. Growth of sooty moulds on honeydew produced by scales reduces the market value of plants and produce (Pellizzari & Camporese, 1994).	
Chrysomphalus dictyospermi (Morgan) [Hemiptera: Diaspididae]	Palm scale	Yes	Armoured scales infest any part of a plant, although areas close to leaf veins and underside of leaves are preferred. Mobile nymphs settle on the upper surface of older leaves, and later on new shoots and immature fruits (HYPPZ, 2003). Heavily infested leaves dry up and fall. Branches wilt. Infested fruits are deformed.	**Yes**
Dialeurodes citri (Ashmead) [Hemiptera: Aleyrodidae]	Citrus whitefly	No	Injures the plant by consuming large quantities of sap. Further injury is caused by sooty mould fungi, which grow over fruit and foliage in the copious honeydew excreted by the whitefly. Heavily infested trees become weak and produce small crops of insipid fruit. Transport of living host plants or fresh foliage of host plants present the main quarantine risk (Fasulo, 1999).	
Lepidosaphes gloverii (Packard) [Hemiptera: Diaspididae]	Glover's scale	Yes	Occurs on most parts of a citrus tree, on fruit, leaves, twigs and sometimes larger limbs. Crawlers settle in sheltered sites, in older leaves and beneath fruit calyx lobes (Smith *et al*., 1997).	**Yes**
Metcalfa pruinosa (Say) [Hemiptera: Flatidae]	Citrus planthopper	No	Primarily feeds on foliage and overwinters as eggs inserted in woody tissue or under tree bark (Wilson & McPherson, 1981). Nymphs surround themselves with long, waxy filaments, which protect them from their copious honeydew.	

Pest	**Common name**	**Pathway association**		**Consider further (yes/no)**
		Associated with fruit (yes/no)	Comment	
Neoaliturus tenellus (Baker) [Hemiptera: Cicadellidae]	Beet leafhopper	No	Primarily feeds on leaves and stems of host plants. Brassicae are the principal host of this insect. In North America, Aizoaceae, Chenopodiaceae and other arid-adapted plants serve as secondary hosts. Eggs are laid in the leaves and stems of the host plants. Eggs hatch from 5 days to 1 month, depending on temperature (Cook, 1941).	
Orthezia insignis Browne Hemiptera: Ortheziidae]	Lantana bug	No	Polyphagous, usually preferring woody hosts, occurring mainly on shoots and twigs (Ezzat, 1956).	
Parabemisia myricae (Kuwana) [Hemiptera: Aleyrodidae]	Bayberry whitefly	Yes	Primarily feeds on the foliage. Eggs are laid on leaf edges or on the upper surface of very young leaves. At high population densities, eggs may also be laid on young fruit and young shoots (Uygun *et al*., 1990).	**Yes**
Parlatoria pergandii Comstock [Hemiptera: Diaspididae]	Chaff scale	Yes	Found on bark, leaves and fruits. When fruit is infested, the areas around the scale remain green at maturity. Chaff scale can also be found under the calyx of the fruit (Futch *et al*., 2001).	**Yes**
Parlatoria ziziphi (Lucas) [Hemiptera: Diaspididae]	Black parlatoria scale	Yes	Heavy infestations cause chlorosis and premature drop of leaves, dieback of twigs and branches, stunting and distortion and fruit drop before maturity. Individuals can be so firmly attached to fruit that they cannot be removed by washing (Fasulo & Brooks, 2001).	**Yes**
Parthenolecanium corni (Bouché) [Hemiptera: Coccidae]	European fruit scale	No	This soft scale sucks plant juices from leaves and twigs. They settle mostly on the underside of leaves, especially along the veins during spring, moving back to the twigs in autumn (Hodgson & Henderson, 2000).	
Phenacoccus madeirensis Green [Hemiptera: Pseudococcidae]	Madeira mealybug	No	Mealybugs are slow moving sucking insects. Mealybug infestations often occur underneath foliage and in hidden areas within dense foliage. Mealybugs remove sap from plants, which can cause yellowing of leaves and decline in vigour. Mealybug ovisacs and excreted honeydew are unsightly. Honeydew supports the growth of black sooty mould fungi and attracts ants. Ants may then carry mealybugs to uninfested plants and tend them for honeydew. Feeding occurs on underside of leaves and preference is shown for leaf ribs (CABI, 2004).	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococccidae]	Citrophilus mealybug	Yes	This mealybug primarily feeds on foliage but can feed on fruit and lays several hundred eggs on the leaves or twigs of its host plants (Rotundo *et* al., 1979). Adults and larvae cause damage by excreting honeydew onto fruit and leaves, leading to sooty mould growth (Grimes & Cone, 1985).	**Yes**
Pterochloroides persicae (Cholodkovsky) [Hemiptera: Aphididae]	Brown peach aphid	No	Eggs are deposited on stems and branches. These aphids pierce the bark and feed on sap (CABI, 2004).	
Pulvinaria floccifera Westwood [Hemiptera: Coccidae]	Cushion scale	No	Other species of this genus are primarily foliage feeders causing yellowing, defoliation, reduction in fruit set and loss of plant vigour (Mau & Kessing, 1992).	
Trioza alacris Flor [Hemiptera: Triozidae]	Laurel psyllid	No	Other species of this genus primarily feed on young leaves, are temperature sensitive and transmit the causal agent of greening disease (Massonie *et al*., 1976).	
Unaspis yanonensis (Kuwana) [Hemiptera: Diaspididae]	Arrowhead scale	Yes	Fruits, leaves and small branches are attacked, but not large branches or trunks. Only the second and third generations are found on fruits (Ohkubo, 1980).	**Yes**
Hymenoptera (ants, wasps)				
Aphanogmus steinitzi Priesner [Hymenoptera: Ceraphronidae]	Wasp	No	Ceraphronidae wasps are parasitic or hyperparasitic (Naumann, 1991). This wasp is a general predator that feeds on a variety of insects including 3rd to 4th stage leafroller caterpillars. The larvae of the wasp feed externally on the caterpillar.	
Aphytis chilensis Howard [Hymenoptera: Aphelinidae]	Parasitic wasp	No	An important parasitoid of the oleander scale, *Aspidiotus nerii* Bouché. *Aphytis chilensis* is an ectoparasitoid of armoured scale insects. The 2nd stage nymphs, young females and scale prepupae are attacked, but the ovipositing females are the preferred stage for parasitization (Alexandrakis & Neuenschwander, 1980).	
Cales noacki (Howard) [Hymenoptera: Aphelinidae]	Parasitic wasp	No	*Cales noacki* is a parasite of Mediterranean origin that is effective against *Aleurothrixus floccosus* (CABI, 2004).	
Camponotus nylanderi Emery [Hymenoptera: Formicidae]	Black ant	No	Colonies of this ant are commonly constructed under the cover of stones, boards, and other objects or at the base of plants.	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Leptomastix dactilopii Howard [Hymenoptera: Encyrtidae]	Mealybug parasite	No	Primarily a parasite of *Planococcus citri*.	
Lysiphlebus testaceipes (Cresson) [Hymenoptera: Aphidiinae]	Parasitic wasp	No	This species only attacks aphids. The conspicuous sign of its activity is the presence of aphid "mummies" - swollen, dead aphids that have been tanned and hardened to form a protective case for the developing wasp pupa (Hoffmann & Frodsham, 1993).	
Tapinoma erraticum (Latreille) [Hymenoptera: Formicidae]	Black ant	No	A very thermophilic species, it is found principally in sandy or peat soil exposed to the sun. Colonies are polygynous and have been recorded to contain up to 40 deälated females. Nests are shallow and small solaria often feature in nest structure to concentrate solar heat onto the ants' brood (Wikipedia, 2004).	
Tapinoma nigerrimum (Nylander) [Hymenoptera: Formicidae]	Black ant	No	Other species of this genus are associated with human habitation and hospitals in particular. These ants feed on many household foods.	
Lepidoptera (moths, butterflies)				
Archips rosanus Linnaeus [Lepidoptera: Tortricidae]	European leaf roller	No	Larvae initially feed in the developing flower-bud trusses and eventually feed within spun or curled leaves. Feeding damage is seen on foliage, buds and developing fruitlets (AliNiazee, 1977; Chepurnaya & Rybalov, 1981), which subsequently heal leaving unsightly corky scars. This suggests that any larvae present on the developing fruitlet would have pupated before the fruit harvest.	
Cacoecimorpha pronubana Hübner [Lepidoptera: Tortricidae]	Mediterranean carnation tortrix	No	Indigenous to the Mediterranean region, primarily feeds on foliage. Eggs are laid on smooth surfaces, which hatch after 6-22 days (van de Vrie, 1991). The larvae quickly move or are carried in wind to the young growing points or flowers. The adults can disperse themselves locally. In international trade, it may be carried on plants for planting or cut flowers of carnations, chrysanthemums, pelargoniums, roses and other host plants. In Algeria, it is found mainly on lemons, but is not considered a serious pest. In Sicily, surveys reported *C. pronubana* mainly on olives, weeds and roses but not on lemons (Inserra *et al*., 1987; Siscaro *et al*., 1988).	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Charaxes jasius (Linnaeus) [Lepidoptera: Nymphalidae]	Two-tailed Pasha	No	The primary food plant for this butterfly is *Arbutus* (strawberry tree). However, the larvae have been noted to feed on citrus leaves (Longo, 1992).	`
Cryptoblabes gnidiella (Millière) [Lepidoptera: Pyralidae]	Citrus pyralid	Yes	The symptoms vary according to the feeding site, but the presence of silk, which indicates larval activity, is normally the most obvious symptom of damage by this pest. Eggs are laid on the fruit or foliage (Carter, 1984).	**Yes**
Gymnoscelis rufifasciata (Haworth) [Lepidoptera: Geometridae]		No	Primarily feeds on citrus flowers (Mineo, 1986).	
Hyphantria cunea Drury [Lepidoptera: Arctiidae]	Fall web-worm	No	External leaf feeder. Woven silk nests enclosing several leaves are conspicuous. Rapid defoliation of forest and fruit trees occurs (Morris, 1976).	
Peridroma saucia (Hübner) [Lepidoptera: Noctuidae]	Variegated cutworm	No	Feeds on leaves of a wide variety of hosts (Berry & Shields, 1980). This species is known to climb the stems of other herbaceous plants, vines, shrubs, and trees and eat buds, leaves and fruits of vegetables and orchard and vineyard crops (Mau & Kessing, 1991). Eggs are laid on the foliage and fully grown larvae are 20 cm long.	
Prays citri Millière [Lepidoptera: Yponomeutidae]	Citrus flower moth	Yes	Eggs are laid individually on the flowers, and sometimes on young fruit. On hatching the larvae bore into flowers and small fruits. Cocoons may be found on fruits, flowers and leaves (Garrido & Ventura, 1993).	**Yes**
Spodoptera littoralis (Boisduval) [Lepidoptera: Noctuidae]	Mediterranean climbing cutworm	No	Polyphagous, generalist feeder recorded on a wide range of plant species. Leaf eating is the main cause of damage to the host plant (HYPPZ, 2004).	
Trichoplusia ni (Hübner) [Lepidoptera: Noctuidae]	Silver moth	No	Larvae feed on the foliage of a wide variety of cultivated plants and weeds. Not all hosts are equivalent for larval development and survival (Hoo *et al*., 1984). Adults feed on nectar from a wide range of flowering plants	
Xestia c-nigrum (Linnaeus) [Lepidoptera: Noctuidae]	Spotted cutworm	No	Larvae feed on a wide range of herbaceous plants, both weedy and agriculturally important species. Eggs are usually laid on suitable host plants but may also be scattered on the soil under plants (Cayrol, 1972). Larvae feed on developing shoots and buds (CABI, 2004).	
Neuroptera (Lacewings)				

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Anisochrysa venusta [Neuroptera: Chrysopidae]	Lacewing	No	Other species of this genus are predators of aphids, white flies and insect eggs. Larval stage is fiercely predatory. The adults reportedly feed on pollen, nectar and aphid honeydew (Canard, 1998).	
Chrysopa carnea Stephens [Neuroptera: Chrysopidae]	Green Lacewing	No	Larvae are voracious and efficient predators of aphids. The adult green lacewing is not a predator but feeds on nectar, honeydew and pollen (CABI, 2004).	
Conwentzia psociformi (Curtis) [Neuroptera: Coniopterygidae]	Lacewing	No	Lacewings are predators and this species is a natural enemy of aphids (CABI, 2004).	
Thysanoptera (thrips)				
Aeolothrips ericae Bagnall [Thysanoptera: Thripidae]	Predatory thrips	No	Attacks a range of plant eating thrips, mites and aphids. These thrips supplement their diet with pollen and plant juice (Hoddle, 1999).	
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips	Yes	Western flower thrips is primarily a flower feeder that eats both the flower petals and pollen. They also feed on foliage of certain hosts and produce a characteristic silvery appearance of thrips damage. Fruit scarring occurs on cucumber (Rosenheim *et al*., 1990) and table grapes (Lewis, 1997). Western flower thrips has been occasionally found associated with fruit (Grafton- Cardwell *et al*., 2005).	**Yes**
Thrips alni Uzel [Thysanoptera: Thripidae]	Flower thrips	No	Recorded on citrus flowers and did not cause scarring on fruitlets (Longo, 1986).	
Thrips falvus Shrank [Thysanoptera: Thripidae]	Flower thrips	No	Recorded on citrus flowers and did not cause scarring on fruitlets (Conti *et al*., 2002).	
Thrips urticae Fabr. [Thysanoptera: Thripidae]	Flower thrips	No	Recorded on citrus flowers and did not cause scarring on fruitlets (Longo, 1986).	
PREDATORY MITES				
Acari (mites)				
Amblydromella rhenanoides (Athias-Henriot) [Acari: Phytoseiidae]	Phytoseiid mite	Yes	Found on leaves and fruits of citrus species in Sicily (Vacante & Nucifora, 1986a).	**Yes**

Pest	**Common name**	**Pathway association**		**Consider further (yes/no)**
		Associated with fruit (yes/no)	Comment	
Amblyseius aberrans (Oudemans) [Acari: Phytoseiidae]	Phytoseiid mite	Yes	This mite preys on phytophagous mites i.e. *Bryobia rubrioculus* and *Cecidophyopsis ribis* in Europe, *Cenopalpus lineola* and *Colomerus vitis* in South Africa, *Eotetranychus carpini*, *Eotetranychus carpini vitis*, *Myzocallis coryli*, *Panonychus ulmi* and *Phytoptus avellanae* (CABI, 2004).	**Yes**
Amblyseius barkeri (Hughes) [Acari: Phytoseiidae]	Phytoseiid mite	Yes	This mite preys on *Frankliniella occidentalis*, *F. intosa*, *Thrips tabaci*, *T. palmi* and *Parthenothrips dracaenae*, although the predator can survive on pollen. Also recorded as preying on *Polyphagotarsonemus latus*, *Tetranychus kanzawai* and *Tyrophagus putrescentiae* (CABI, 2004).	**Yes**
Amblyseius degenerans (Berlese) [Acari: Phytoseiidae]	Phytoseiid mite	Yes	This mite preys on *Frankliniella occidentalis*. *Thrips tabaci* are less favored as prey. The predator will eat the spider mites *Polyphagotarsonemus latus* and *Tetranychus urticae* and can survive on pollen (CABI, 2004).	**Yes**
Amblyseius italicus Chant [Acari: Phytoseiidae]	Phytoseiid mite	Yes	Predator of *Panonychus ulmi* (CABI, 2004).	**Yes**
Amblyseius potentillae (Garman) [Acari: Phytoseiidae]	Phytoseiid mite	Yes	Predator of *Aculus schlechtendali*, *Cecidophyopsis ribis* and *Panonychus ulmi* (CABI, 2004).	**Yes**
Amblyseius stipulatus Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite	Yes	Predator of *Panonychus ulmi*, *Aculus fockeui* and *Cenopalpus lineola* (CABI, 2004).	**Yes**
Amblyseius swirskii Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite	Yes	Predator of *Aphis gossypii*, *Brevipalpus californicus*, *Eutetranychus orientalis*, *Metaculus mangiferae*, *Parabemisia myricae*, *Pseudococcus cryptus*, *Tetranychus cinnabarinus* and *Thrips tabaci* (CABI, 2004). This species is found in association with prey (*Aphis gossypii*, *Brevipalpus californicus*, *Eutetranychus orientalis*, *Metaculus mangiferae*, *Parabemisia myricae*, *Pseudococcus cryptus*, *Tetranychus cinnabarinus* and *Thrips tabaci*) that can be associated with the fruit pathway.	**Yes**
Calvolia hebeclinii Sicher [Acari: Saproglyphidae]	Saproglyphid mite	No	Species of this genus have been recorded as fungus feeders (Oatman, 1973), phoretic on tabanid flies (Mullen *et al.*, 1989) and associated with bark beetles (Kielczewski & Seniczak, 1972). This genus has been placed in the families Wintershmidtiidae and Glycyphagidae by other authors.	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Cheletogenes ornatus (Canestrini & Fanzago) [Acari: Cheyletidae]	Cheyletid mite	Yes	Preys on *Brevipalpus californicus*, *Cenopalpus pulcher*, *Parlatoria oleae*, *Pinnaspis aspidistrae*, *Pinnaspis strachani* and *Pseudaulacaspis cockerelli* (CABI, 2004). This species is found in association with prey (*Brevipalpus californicus*) that can be associated with the fruit pathway.	**Yes**
Cheletomimus berlesei (Oudemans) [Acari: Cheyletidae]	Cheyletid mite	No	Natural enemy of the leaf feeding pests *Cenopalpus lineola* and *Hemiberlesia lataniae* (CABI, 2004).	
Cheletomimus minutes (Oudemans) [Acari: Cheyletidae]	Cheyletid mite	Yes	Cheyletid mites are mostly free-living predators found in association with prey that includes acarids, tetranychids and scales (Baker & Wharton, 1952). This species is found in association with prey that includes tetranychids (*Panonychus citri*) and scales (*Lepidosaphes gloverii*) that can be associated with the fruit pathway.	**Yes**
Cunaxa capreolus (Berlese) [Acari: Cunaxidae]	Cunaxid mite	No	This mite is recorded mainly from leaf litter but also in citrus trees in Florida. It is a predaceous mite that feeds on Psocopterans and *Eutetranychus orientalis* (Muma *et al.*, 1975), a leaf-feeding pest (CABI, 2004).	
Cunaxa setirostris (Hermann) [Acari: Cunaxidae]	Cunaxid mite	No	A predator found sporadically on lemon leaves and twigs in Sicily (Vacante & Nucifora, 1986a).	
Cunaxoides oliveri Schruft [Acari: Cunaxidae]	Cunaxid mite	Yes	Cunaxid mites are considered to be a predatory genus that feed on scale insects and small arthropods (Smiley, 1975). *Cunaxoides* species are listed as potential predators of *Scirtothrips aurantii* (Milne, 1977). As this mite is predatory on small arthropods (*Panonychus citri)* and scales (*Lepidosaphes gloverii*), it is considered associated with the pathway.	**Yes**
Eryngiopus bifidus Wood [Acari: Stigmaeidae]	Stigmaeid mite	Yes	Mites of this genus are predatory and are recorded to attack *Aonidiella aurantii* (Krishnamoorty & Rajagopal, 1999). This species is found in association with prey (*Aonidiella aurantii*) that can be associated with the fruit pathway.	**Yes**
Eryngiopus siculus Vacante & Gerson [Acari: Stigmaeidae]	Stigmaeid mite	Yes	Mites of this genus are predatory and are recorded as attacking *Aonidiella aurantii* (Krishnamoorty & Rajagopal, 1999). This species is found in association with prey (*Aonidiella aurantii*) that can be associated with the fruit pathway.	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Eutogenes citri Gerson [Acari: Cheyletidae]	Cheyletid mite	Yes	Cheyletid mites are mostly free-living predators found in association with prey that includes acarids, tetranychids and scales (Baker & Wharton, 1952). This species is found in association with prey that includes tetranychids (*Panonychus citri*) and scales (*Lepidosaphes gloverii*) that can be associated with the fruit pathway.	**Yes**
Hemisarcoptes malus (Shimer) [Acari: Hemisarcoptidae]	Hemisarcoptid mite	Yes	A minute predaceous mite, which feeds on scale insects (Vacante, 1989).	**Yes**
Hirstiella insignis Berlese [Acari: Pterygosomatidae]	Pterygosomatid mite	No	Mites of the genus *Hirstiella* are parasites of lizards and iguanas (Baker, 1998; Walter & Shaw, 2002).	
Ledermuelleriopsis plumosus Willmann [Acari: Stigmaeidae]	Stigmaeid mite	No	Found on leaf litter, mould and in soil (Fan *et al.*, 2003).	
Mediolata similans Willmann [Acari: Stigmaeidae]	Stigmaeid mite	No	This mite is a predator (Komlovsky & Jenser, 1992) of the leaf feeding pests.	
Neoseiulus californicus McGregor [Acari: Phytoseiidae]	Phytoseiid mite	Yes	Predator of *Polyphagotarsonemus latus* in Italy. It will survive on other small arthropods and on pollen but it will not reproduce in the absence of spider mites (CABI, 2004). This species is found in association with prey that includes spider mites (*Panonychus citri, Polyphagotarsonemus latus*) that can be associated with the fruit pathway.	**Yes**
Phytoseiulus finitimus Ribaga [Acari: Phytoseiidae]	Phytoseiid mite	No	Other species of this genus are one of the mainstays of greenhouse integrated pest management programs for control of spider mites on vegetables and ornamentals.	
Phytoseiulus panormita Ragusa & Swirski [Acari: Phytoseiidae]	Phytoseiid mite	No	Other species of this genus are one of the mainstays of greenhouse integrated pest management programs for control of spider mites on vegetables and ornamentals.	
Seiulus amaliae Ragusa & Swirski [Acari: Phytoseiidae]	Phytoseiid mite	No	A predatory mite found on leaves (Vacante & Nucifora, 1986a).	
Seiulus finlandicus (Oudemans) [Acari: Phytoseiidae]	Phytoseiid mite	No	Predator of *Aculus schlechtendali*, *Cecidophyopsis ribis* and *Panonychus ulmi* (CABI, 2004).	

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Typhlodromus athenas Porath & Swirski [Acari: Phytoseiidae]	Phytoseiid mite	No	A predatory mite present on leaves of orange and lemon (Vacante & Nucifora, 1986a).	
Typhlodromus cryptus (Oudemans) [Acari: Phytoseiidae]	Phytoseiid mite	No	A predatory mite found on leaves of lemon, orange and mandarin (Vacante & Nucifora, 1986a).	
Typhlodromus exhilaratus Ragusa [Acari: Phytoseiidae]	Phytoseiid mite	Yes	A predatory mite found on leaves and fruit of citrus (Vacante & Nucifora, 1986a).	**Yes**
Typhlodromus phialatus Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite	Yes	Frequent predator of *Panonychus ulmi* in Spain (Ferragut *et al.*, 1992).	**Yes**
Amblydromella rhenanoides (Athias-Henriot) [Acari: Phytoseiidae]	Phytoseiid mite	Yes	A predatory mite found on leaves and fruit of citrus (Vacante & Nucifora, 1986a).	**Yes**
Typhlodromus talbii Athias-Henriot [Acari: Phytoseiidae]	Phytoseiid mite	Yes	This mite is a predator of economic pests, especially in vineyards (Camporese & Duso, 1995). Preys on tydeid, tetranychids and eriophyid mites. This species is found in association with prey that includes tetranychids (*Panonychus citri*) and eriophyid mites (*Aculops pelekassi*) that can be associated with the fruit pathway. Therefore, this species is associated with the fruit pathway.	**Yes**
Zetzellia collyerae (Gonzalez-Rodriguez) [Acari: Stigmaeidae]	Stigmaeid mite	Yes	This genus of stigmaeid mites is reported as predators of tetranychid and eriophyid mites (Clements & Harmsen, 1990; O'Dowd, 1994). This species is found in association with prey that includes tetranychids (*Panonychus citri*) and eriophyid mites (*Aculops pelekassi*) that can be associated with the fruit pathway. Therefore, this species is associated with the fruit pathway.	**Yes**
Zetzellia graeciana Gonzales [Acari: Stigmaeidae]	Stigmaeid mite	Yes	This genus of stigmaeid mites is reported as predators of tetranychid and eriophyid mites (Clements & Harmsen, 1990). This predatory species was present on buds and leaves, but not on fruit, in Italy (Vacante & Nucifora, 1986a). This species is found in association with prey that includes tetranychids (*Panonychus citri*) and eriophyid mites (*Aculops pelekassi*) that can be associated with the fruit pathway. Therefore, this species is associated with the fruit pathway.	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Zetzellia mali (Ewing) [Acari: Stigmaeidae]	Stigmaeid mite	Yes	This genus of stigmaeid mites is reported as predators of tetranychid and eriophyid mites (Clements & Harmsen, 1990; O'Dowd, 1994). This species is found in association with prey that includes tetranychids (*Panonychus citri*) and eriophyid mites (*Aculops pelekassi*) that can be associated with the fruit pathway. Therefore, this species is associated with the fruit pathway.	**Yes**
PATHOGENS				
Fungi				
Armillaria mellea (Vahl) P. Kummer	Armillaria root rot	No	A root pathogen (Timmer *et al*., 2000).	
Armillaria tabescens (Scop.) Dennis, P.D. Orton & Hora	Armillaria root rot	No	A root pathogen. Causes slow decline of trees, with leaf yellowing and leaf drop (Timmer *et al*., 2000).	
Ascochyta hesperidearum Penz. In Sacc.	Leaf spot	No	Recorded on withering and living leaves of *Citrus limonum* and *Limonia australis* (Mel'nik *et al.* 2000).	
Capnodium citri Mont.	Sooty mould	Yes	This fungus is found on fruit and leaves and grows superficially on the honeydew excretions of aphids, scales, mealybugs and psyllids (Baker *et al*., 2002). Spores or fragments of sooty mould are carried to the honeydew and new colonies of sooty mould develop. Although the fungal threads may adhere to the plant surface, sooty mould does not parasitise plant tissue (Baker *et al*., 2002).	**Yes**
Cercospora penzigii Sacc.	Leaf spot	Yes	Causes leaf spot of sweet orange leaves (Timmer *et al*., 2000). Most recently this fungus has been reported with citrus fruit in South Africa (Pretorius *et al*., 2003).	**Yes**
Nematospora coryli Peglion	Yeast spot	Yes	This fungus is reported to cause desiccation, dry rot and premature fruit drop of oranges, grape fruit and tangerines in 1920s (Fawcett, 1929) and is transmitted by insects (Mukerji, 1968).	**Yes**
Phoma tracheiphila (Petri) Kantachveli & Gikachvili	Mal secco	Yes	*Phoma tracheiphila* causes a serious tracheomycotic disease in various *Citrus* species, especially in lemon in the Mediterranean basin. This pathogen has been detected in lemon seeds (Stepanov & Shaluishkina, 1952).	**Yes**

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Phytophthora palmivora (E. J. Butler) E. J. Butler	Brown rot	Yes	The fungus is splashed onto fruit from the soil and cause brown rot. This fungus is known to produce air-borne sporangia and can affect fruit throughout the canopy (Graham & Timmer, 2004).	**Yes**
Phytophthora syringae (Kleb.) Kleb.	Brown rot	Yes	This fungus is known to cause brown rot of citrus in the Mediterranean climates (Timmer *et al*., 2000).	**Yes**
Septoria citri Pass	Septoria spot	Yes	Primarily associated with foliage but is also reported as causing damage to fruit rind (Timmer *et al*., 2000).	**Yes**
Nematodes				
Crossonema multisquamatum (Kirjanova) Mehta & Raski		No	All stages feed on the root tips (ANN, 1998).	
Rotylenchulus macrodoratus Dasgupta *et al*.	Reniform nematode	No	*Rotylenchulus macrodoratus* is a Mediterranean species parasitizing many fruit trees including almond, apricot, citrus, fig, grape, laurel, loquat, oleander, olive, oak, pistachio and plum. Primarily a root feeder (Robinson *et al*., 1997).	
Xiphinema index Thorne & Allen	Dagger nematode	No	Migratory root ectoparasite; all stages feed at root tips. Reproduction is by meiotic parthenogenesis (Siddiqi, 1986).	
Phytoplasma				
Spiroplasma citri Saglio *et al*.	Stubborn	No	An obligate parasite, surviving in citrus or in a variety of other host plants. Naturally transmitted by leafhoppers (Klein *et al*., 1988). Natural transmission by leafhoppers will only carry this pathogen over local distances. International spread is more likely to occur with infected budwood (although this does not transmit the pathogen very reliably). Although the possibility exists that infective vectors may be carried on citrus plants, the insects concerned are actively mobile and do not preferentially feed on citrus, so the risk is considered minimal.	
Viroids				

Pest	Common name	Pathway association		Consider further (yes/no)
		Associated with fruit (yes/no)	Comment	
Citrus exocortis viroid	Citrus exocortis	No	Grafting readily transmits this viroid. It is not vectored or seed transmitted (Timmer *et al*., 2000).	
Citrus xyloporosis viroid	Citrus cachexia	No	Grafting readily transmits this viroid. It is not vectored or seed transmitted (Timmer *et al*., 2000).	
Citrus viroid IV (CVd-IV)	Citrus viroid	No	Grafting readily transmit this viroid. It is not vectored or seed transmitted (Hadidi *et al*. 2003).	
Citrus viroid IV (CVd-IV)	Citrus viroid	No	Grafting readily transmit this viroid. It is not vectored or seed transmitted (Hadidi *et al*. 2003).	
Citrus bent leaf IV (CBLVd)	Citrus bent leaf viroid	No	Grafting readily transmit this viroid. It is not vectored or seed transmitted (Hadidi *et al*. 2003).	
Viruses				
Citrus impietratura virus	Citrus impietratura disease	No	Grafting readily transmits this virus. It is not vectored or seed transmitted (Timmer *et al*., 2000).	
Citrus ring spot virus (CRSV)	Psorosis complex A & B	No	Graft-transmitted disease (Timmer *et al*., 2000).	
Citrus variegation virus	Variegation disease	No	Graft-transmitted disease (Timmer *et al*., 2000).	

Appendix – 1c: Potential for Establishment or Spread and Associated Consequences for Pests of Sweet Oranges from Italy

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
ARTHROPODS						
Acari (mites)						
Aculops pelekassi (Keifer) [Acari: Eriophyidae]	Pink citrus rust mite	Feasible	Narrow host range (Benfatto, 1980), but high reproductive rate (Mijuskovic & Kosac, 1972). Dispersed by wind.	Significant	Direct economic losses occur when distorted fruit is downgraded in packinghouses.	**Yes**
Panonychus citri McGregor [Acari: Tetranychidae]	Citrus red mite	Feasible	Wide host range (Bolland *et al*., 1998) and already established in restricted areas of New South Wales (Hely *et al*., 1982) indicating suitability of the environment for establishment.	Significant	This mite is considered to be an economically important pest of citrus crops (Jeppson *et al*., 1975).	**Yes**
Lorryia ferula Baker [Acari: Tydeidae]	Tydeid mite	Feasible	Restricted host range (Vacante & Nucifera, 1986).	Not significant	There are no published reports on economic losses caused by this mite.	
Lorryia formosa Cooreman [Acari: Tydeidae]	Yellow mite	Feasible	Wide host range (Jeppson *et al*., 1975).	Significant	*Lorryia formosa* has been found damaging citrus (Jeppson *et al*., 1975).	**Yes**
Pronematus ubiquitus (McGregor) [Acari: Tydeidae]	Tydeid mite	Feasible	Restricted host range (Vacante & Nucifera, 1986).	Not significant	There are no published reports on economic losses caused by this mite.	
Tarsonemus aurantii Oudemans [Acari: Tarsonemidae]	Tarsonemid mite	Feasible	• Tarsonemid feeding habits are greatly diverse: many are fungivores, algivorus and others are predators of other mites, parasites of insects and possibly symbiont of insects (Lin & Zhang,	Not significant	• Some phytophagous tarsonemids are important pest on agricultural crops (Lin & Zhang, 2001). However, these species are fungivores. • Not associated with damage	
Tarsonemus bilobatus Suski [Acari: Tarsonemidae]	Tarsonemid mite					

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Tarsonemus floricolus Canestrini & Fangazo [Acari: Tarsonemidae]	Tarsonemid mite		2001). • *Tarsonemus parawaitei* and *Tarsonemus waitei* are already established across Australia (Kim *et al*., 1987; Smith *et al*., 1997) indicating suitability of the environment for establishment.		(McLaren *et al*., 1999).	
Tarsonemus idaeus Suski [Acari: Tarsonemidae]	Tarsonemid mite					
Diptera (flies)						
Ceratitis capitata Wiedemann) [Diptera: Thripidae]	Mediterranean fruit fly; Medfly	Feasible	Polyphagous, with a wide host range. Strong flyer- adults can fly up to 20 km (Fletcher, 1989). Females pierce the skin of fruit and lay eggs. Larvae feed internally on fruit (Knapp, 1998).	Significant	Economic impact would occur primarily though domestic and international trading restrictions imposed on fruit from areas where Medfly becomes established.	**Yes**
Hemiptera (aphids, leafhoppers, mealybugs, psyllids, scales, true bugs and whiteflies)						
Aleurothrixus floccosus (Maskell) [Hemiptera: Aleyrodidae]	Woolly whitefly	Feasible	Wide host range and high reproductive rates (Vulic & Beltran, 1977). Weak flier and seldom takes flight when disturbed or flies only short distances.	Significant	Damage is direct through sap removal and indirect through reduction of photosynthesis as a result of sooty mould development (Reuther *et al*., 1989).	**Yes**
Chrysomphalus dictyospermi (Morgan) [Hemiptera: Diaspididae]	Palm scale	Feasible	Wide host range (HYPPZ, 2003) and already established in Queensland (AICN, 2004).	Significant	Infested fruits are deformed (HYPPZ, 2003) and would be downgraded during packing house procedures.	**Yes**
Lepidosaphes gloverii (Packard) [Hemiptera: Diaspididae]	Glover's scale	Feasible	Wide host range (Davidson & Miller, 1990) and already established in New South Wales and Queensland (Smith *et al*., 1997).	Significant	Heavy infestation can cause a delay in the development of colour in maturing fruit (Bruwer, 1998).	**Yes**
Parabemisia myricae (Kuwana) [Hemiptera: Aleyrodidae]	Bayberry whitefly	Feasible	Wide host range (Mound & Halsey, 1978) and high reproductive rates (Rose *et al*., 1981).	Significant	Damage is direct through sap removal and indirect through reduction of photosynthesis as a result of sooty mould development.	**Yes**

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Parlatoria pergandii Comstock [Hemiptera: Diaspididae]	Chaff scale	Feasible	Restricted host range (Davidson & Lyon, 1987). Already established in Queensland (Smith *et al*., 1997).	Significant	Causes green spots on fruit making them unsuitable for the fresh market (Cartwright & Browning, 2003).	**Yes**
Parlatoria ziziphi (Lucas) [Hemiptera: Diaspididae]	Black parlatoria scale	Feasible	Wide host range (Fasulo & Brooks, 2001).	Significant	Causes defoliation, reduction in plant vigour, distortion and stunting of fruit, and premature fruit drop.	**Yes**
Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae]	Citrophilus mealybug	Feasible	Wide host range (Ben-Dov, 1994), high reproductive rates (Rotundo *et al*., 1979) and already established in New South Wales, Queensland, South Australia, Tasmania and Victoria (AICN, 2004).	Significant	Infested fruit is downgraded for fresh markets (Howitt, 2001).	**Yes**
Unaspis yanonensis (Kuwana) [Hemiptera: Diaspididae]	Arrowhead scale	Feasible	Narrow host range (Nohara, 1962) and high reproductive rates (Ohkubo, 1980).	Significant	Principal pest of *Citrus* In Japan (Ohkubo, 1980).	**Yes**
Lepidoptera (butterflies, moths)						
Cryptoblabes gnidiella (Millière) [Lepidoptera: Pyralidae]	Citrus pyralid	Feasible	Polyphagous (Karsholt, 1996) with a high reproductive rate (Wysoki *et al*., 1993). Individual moths may make extended flights to new fields (Silva & Mexia, 1999).	Significant	Feeding of larvae can result in cosmetic degradation of fresh fruit (Hashem *et al*., 1997).	**Yes**

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Prays citri Millière [Lepidoptera: Yponomeutidae]	Citrus flower moth	Feasible	Narrow host range (Sinacori & Mineo, 1997) and high reproductive rate (Mineo *et al*., 1980). Individual moths may make extended flights to new fields.	Significant	Feeding of larvae can result in cosmetic degradation of fresh fruit (Ibrahim & Shahateh, 1984).	**Yes**
Thysanoptera (thrips)						
Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae]	Western flower thrips	Feasible	Polyphagous pest and high reproductive rates (Mound & Teulon, 1995). Already established in Australia (AICN, 2004).	Significant	WFT damage plants directly by feeding and laying eggs on the plant (Childers & Achor, 1995), and indirectly by acting as vectors for viruses.	**Yes**
PREDATORY MITES						
Acari: Cheyletidae						
Cheletogenes ornatus (Canestrini & Fanzago)	Cheyletid mite	Feasible	• Cheyletid mites are free living predators (Gerson, 1994). • *Cheletogenes ornatus* feeds on armoured scale insects in many parts of the world (Mehrnejad & Ueckermann, 2001).	Not significant	• Cheyletid mites are not considered to be important predators in IPM systems may be useful as minor/secondary predators (Gerson & Smiley, 1990). • There are no published reports on mutual predation among cheyletid and other mites. Therefore, are unlikely to impact on established IPM systems.	
Cheletomimus minutes (Oudemans)	Cheyletid mite					
Eutogenes citri Gerson	Cheyletid mite					
Acari: Cunaxidae						

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Cunaxoides oliveri Schruft	Cunaxid mite	Feasible	• Cunaxoides species are listed as potential predators of *Scirtothrips aurantii* (Milne, 1977).	Not significant	• There are no published reports on mutual predation among cunaxid mites and other mites. Therefore, are unlikely to impact on established IPM systems.	
Acari: Phytoseiidae						
Amblydromella rhenanoides (Athias-Henriot)	Phytoseiid mite	Feasible	• *Amblyseius* species are generalist predators (McMurtry & Croft, 1997; Croft *et al*., 1998). • Most generalist predators within the family can reproduce on various genera of tetranychid mites and pollens (Duso *et al*., 1991). • A variety of plant exudates and honeydew may serve as food source in the absence of prey. In the presence of prey, these food sources can boost reproductive potential (Bakker & Klein, 1992; McMurtry, 1992). • Some species of this genus are already established across Australia (Halliday, 1998; Whitney & James, 1996), indicating suitability of the environment for establishment.	Significant	• Generalist predators have the potential to damage non-target organisms (Howarth, 1991). • Predacious mites interact interspecifically through competition for prey or feeding on each other (Croft & MacRae, 1993). • Mutual predation reported among predatory mites could result in localised displacement of established mites in the natural ecosystem (Reitz & Trumble, 2002). - *Amblyseius aberrans* has been recorded to displace *Typhlodromus pyri* (Duso *et al*., 1991). - *Typhlodromus pyri* has been recorded to displace *Metaseiulus occidentalis* (Croft & McRae, 1993).	**Yes**
Amblyseius aberrans (Oudemans)	Phytoseiid mite					
Amblyseius barkeri (Hughes)	Phytoseiid mite					
Amblyseius degenerans (Berlese)	Phytoseiid mite					
Amblyseius italicus Chant	Phytoseiid mite					
Amblyseius potentillae (Garman)	Phytoseiid mite					
Amblyseius stipulatus Athias-Henriot	Phytoseiid mite					
Amblyseius swirskii Athias-Henriot	Phytoseiid mite					
Neoseiulus californicus McGregor	Phytoseiid mite					
Typhlodromus exhilaratus Ragusa	Phytoseiid mite					

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Typhlodromus talbii Athias-Henriot	Phytoseiid mite					
Acari: Stigmaeidae						
Eryngiopus bifidus Wood	Stigmaeid mite	Feasible	• Stigmaeid mites feed on a variety of prey that includes European red mite, two-spotted spider mite and other mites such as rust mites and tydeid mites (Weeden *et al*., 2005). • Stigmaeid mites also feed on pollen when mite population levels are low (Weeden *et al*., 2005). • Some species of stigmaeid mites are established across Australia (Halliday, 1998).	Significant	• Stigmaeid mites and phytoseiid mites may interact by feeding on each other or by competition for prey (Croft & MacRae, 1993). • Stigmaeid mites have been reported to feed on phytoseiid mites eggs (Santos & Laing, 1985; Clements & Harmsen, 1990). - *Z. mali* displace populations of *T. pryi* (Croft, 1994) and *Metaseiulus occidentalis* (MacRae & Croft, 1996). • Competition for prey or mutual predation may affect IPM in various ecosystems.	**Yes**
Eryngiopus siculus Vacante & Gerson	Stigmaeid mite					
Zetzellia collyerae (Gonzalez-Rodriguez)	Stigmaeid mite					
Zetzellia graeciana Gonzales	Stigmaeid mite					
Zetzellia mali (Ewing)	Stigmaeid mite					
PATHOGENS						
Fungi						
Capnodium citri Mont.	Sooty mould	Feasible	Narrow host range (Farr *et al*., 1989) and spores are windborne (Baker *et al*., 2002).	Not significant	This fungus does not penetrate the tissue of the plant but grows superficially on honeydew (Baker *et al*., 2002).	
Cercospora penzigii Sacc.	Leaf spot	Feasible	Narrow host range and spread by air-borne conidia (Pretorius *et al*., 2003)	Not significant	Not considered of economic significance in commercially produced fruits for either domestic or international trade.	

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Nematospora coryli Peglion	Dry rot of fruit	Feasible	Wide host range and already established in New South Wales and Queensland (Shivas *et al*., 2005) and is transmitted by insects (Mukerji, 1968).	Significant	*Nematospora coryli* is a known pest of hosts other than citrus and has been documented as causing damage on nut crops (pistachio, macadamia and hazelnut) as well as *Phaseolus* spp. and cotton (Teviotdale *et al*., 2002; Watkin, 1981).	**Yes**
Phoma tracheiphila (Petri) Kantachveli & Gikachvili	Mal secco	Feasible	Narrow host range and transmitted by seeds (Stepanov & Shaluishkina, 1952). Short-distance dispersal is caused by wind and rain (Laviola & Scarito, 1989). Long-distance spread of mal secco occurs through infected propagative material and plants.	Significant	The disease reduces the quantity and quality of lemon production in the areas where the pathogen is present, and limits the use of susceptible species and cultivars (Perrotta & Graniti, 1988).	**Yes**
Phytophthora palmivora (E. J. Butler) E. J. Butler	Brown rot	Feasible	This pathogen has a wide host range and is already established in tropical fruit growing regions of the Northern Territory and Queensland (Ploetz *et al*., 2003). Spores are wind blown (Timmer *et al.,* 2000).	Significant	*Phytophthora palmivora* causes fruit rot in atemoya, breadfruit, papaya, pond apple, soursop, fig, longan and durian (Ploetz *et al*., 2003). It is an important pathogen of cacao.	**Yes**
Phytophthora syringae (Kleb.) Kleb.	Brown rot	Feasible	Wide host range and spores are wind blown (Timmer *et al.,* 2000). Already established in South Australia.	Significant	*Phytophthora syringae* causes collar and fruit rot of apple, leaf spot and shoot dieback of lilac, canker of almond, brown rot and twig and blossom blight of citrus, leaf blight of fennel, stem rot of cacti and root rot and damping-off of seedlings in many other species (Ploetz *et al*., 2003).	**Yes**

Scientific name	Common name	Potential for establishment or spread in the PRA area		Potential for consequences		Consider pest further? (yes/no)
		Feasible/ not feasible	Comments	Significant/ not significant	Comments	
Septoria citri Pass	Septoria spot	Feasible	Restricted host range. Short-distance dispersal is caused by wind and rain.	Significant	*S. citri* is generally considered of minor importance except where the appearance of the fruit is important as damage to the rind can cause fruit to be downgraded. Losses have also been reported where symptoms occur on the tree as it often results in fruit fall (Barkley 2004; Timmer *et al.* 2000).	**Yes**

References

AAN (1998). Agricole ed Agroindustriali Nazionali, Direczione generale delle politicje, Ministero per le Politiche Agricole. Lista completa dei parassiti degli agumi presenti in Italia.

Abbot, I. (1995). Prodromus of the occurrence and distribution of insect species in the forested part of south-west Western Australia. CALM Science 1: 365-464.

Adachi, I. (1990). Population studies of *Anoplophora malasiaca* adults (Coleoptera: Cerambycidae) in a citrus grove. Researches on Population Ecology 32: 15-32.

AICN (2004). Australian Insect Common Names database. http://www.ento.csiro.au/aicn

Alexandrakis, V. and Neuenschwander, P. (1980). Le rôle d' *Aphytis chilensis* (Hymenoptera: Aphelinidae), parasite d' *Aspidiotus nerii* (Homoptera: Diaspididae) sur olivier en Crete. Entomophaga 25: 61-71.

AliNiazee, M.T. (1977). Bionomics and life history of a filbert leafroller, *Archips rosanus* (Lepidoptera: Tortricidae). Annals of the Entomological Society of America 70: 391-401.

Anon (1981). Predators and parasites in Western Australia. Journal of Agriculture – Western Australia 4th Series, 22: 83.

APPD (2004). Australian plant pest database. http://www.planthealthaustralia.com.au/our_projects/display_project.asp?category=4&ID=1

AQIS (1994). Importation of fresh citrus fruit from Florida, USA. An AQIS position paper. Australian Quarantine and Inspection Service, Canberra, Australia. 20 pp.

Badii, H.M., Flores, A.E., Ponce, G., Landeros, J. and Quiroz, H. (2001). Does the *Lorryia formosa* Cooreman (Acari: Prostigmata: Tydeidae) population visit or reside on citrus foliage?, pp 413-418. Acarology: Proceedings of the 10th International Congress, Canberra, Australia. CSIRO Publishing, Collingwood, Victoria.

Baker, A.S. (1998) A new species of *Hirstiella* Berlese (Acari: Pterygosomatidae) from captive rhinoceros iguanas, *Cyclura cornuta* Bonnaterre (Reptilia: Iguanidae). Systematic and Applied Acarology 3: 183-192.

Baker, E.W. and Wharton, G.W. (1952). An Introduction to Acarology. The Macmillan Company, New York.

Baker, J. R., Bambara, S.B. and Jones, R.K. (2002). Sooty mold. Ornamentals and Turf. Department of Entomology Note. NC University. North Carolina Cooperative Extension Service. http://www.ces.ncsu.edu/depts/ent/notes/O&T/houseplants/note41/note41.html

Bakker, F.M and Klein, M.E. (1992). Transtrophic interactions in Cassava. Experimental and Applied Acarology 14: 293-311.

Barbagallo, S., Longo, S. and Rapisarda, C. (1986). Whiteflies and psyllids injurious to citrus, pp 89-99. In: Cavalloro, R., and Di Martino, E. (eds.). Integrated Pest Control in Citrus-Groves: Proceedings of the experts' meeting, Acireale, 26-29 March 1985. Rotterdam, Netherlands: Published for the Commission of the European Community by A.A. Balkema, Rotterdam/Boston.

Barkley, P. (2004). Citrus Diseases and Disorders (2nd Edn.). NSW Agriculture, New South Wales Government.

Bassi, R. (1994). The principal adversities of Plum. Vita in Campagna 12: 33-35

Ben-Dov, Y. (1993). A systematic catalogue of the soft scale insects of the world (Homoptera: Coccoidea: Coccidae) with data on geographical distribution, host plants, biology and economic importance. Sandhill Crane Press Inc., Gainesville, USA. 536 pp

Ben-Dov, Y. (1994). A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance. Intercept Limited, Andover, UK. 686 pp.

Benfatto, D. (1980). The principal citrus mites and their control. Frutticoltura 42: 43-54.

Benfatto, D. and Longo, S. (1986). Beetle pests living on citrus in Italy. In: Cavalloro, R. and Martino, E.D. (eds). Integrated pest control in citrus groves. pp. 127 – 133. Proceedings of the expert's meeting, Acireale, 16-17 March, 1985. Balkema, A.A., Boston Publishers, Totterdam.

Beniecki, J.F. (2002). Vegetable Crop Insects. Pest Information Sheet. Centre for Agriculture, Natural Resources and Community Development, West Virginia University Extension Service. http://www.wvu.edu/~agexten/ipm/pestprog/educate/pestinfo.htm

Berlandier, F.A. (1997). Distribution of aphids (Hemiptera, Aphididae) in potato growing areas of southwestern Australia. Australian Journal of Entomology 36: 365 - 375.

Berry, R.E. and Shields, E.J. (1980). Variegated cutworm: Leaf consumption and economic loss in peppermint. Journal of Economic Entomology 73: 607-608.

Bolland, H.R., Gutierrez, J. and Flechtmann, C.H.W. (1998). World Catalogue of the Spider Mite Family (Acari: Tetranychidae). K. Brill, Leiden, Netherlands. 392 pp.

Booth, R.G. and Pope, R.D. (1986). A review of the genus *Cryptolaemus* (Coleoptera: Coccinellidae) with particular reference to the species resembling *C. montrouzieri* Mulsant. Bulletin of Entomological Research 76: 701-717.

Botha, J. and Learmonth, S. (2005). Management of European red mite in Western Australia. Farmnote.

Bradbury, J.F. (1986). Guide to Plant Pathogenic Bacteria. CAB International Mycological Institute, Kew, UK. 332 pp.

Briese, D. T. and Macauley, B. J. (1981). Food collection within an ant community in semi-arid Australia, with special reference to seed harvesters. Australian Journal of Ecology 6:1-19.

Broughton, S. and De Lima, F. (2002). Monitoring and control of thrips in citrus. Department of Agriculture, Farm Note, No. 7/2002.

Bruwer, I.J. (1998). Long mussel scale *Lepidosaphes gloverii* (Packard), pp 153-157. In: Bedford, E.C.G., Van den Berg, M.A. and De Villiers, E.A. (eds.) Citrus Pests in the Republic of South Africa. Dynamic Ad, Nelspruit, South Africa.

Büchen-Osmond, C. (1988). Virus of plants in Australia. Australian features of viruses – list of viruses. http://www.ictvdb.iacr.ac.uk/Aussi/ausiname.htm

Buckland, P., Curry, S., Davis, P., Emery, R., Gherardi, S., Grimm, M., Goulder, R., Hardie, D., Hill, A., Learmonth, S., Mercy, A., Michael, P., Monzu, N., Moulden, J., Richards, K., Rimes, D., Sandow, J., Woods, W. and Wilkinson, F. (1990). Insect and Allied Pests of Extensive Farming. Bulletin 4185, Western Australian Department of Agriculture.

CABI (2004). Crop Protection Compendium Global Module. CAB International, Wallingford, UK. http://www.cabicompendium.org/cpc/home.asp

CABI/EPPO (1997). *Ceratitis capitata*. Distribution Maps of Plant Diseases, No. 143. CAB International, Wallingford, UK.

CABI/EPPO (1998). *Aonidiella citrina*. Distribution Maps of Quarantine Pests for Europe No. 19. CAB International, Wallingford, UK.

CABI/EPPO (2000). *Phenacoccus madeirensis*. Distribution Maps of Plant Pests, Map No. 607. CAB International, Wallingford, UK.

CABI/EPPO, (2001). *Aphis spiraecola*. Distribution Maps of Plant Pests, Map No. 256. CAB International, Wallingford, UK.

Camporese, P. and Duso, C. (1995). Life history and life table parameters of the predatory mite *Typhlodromus talbii*. Entomologia Experimentalis et Applicata 77: 149-175.

Camporese, P., and Pellizzari, G. (1998). Observations on the biology of *Ceroplastes japonicus* in the urban environment. Informatore Fitopatologico 48: 42-50.

Canard, M. (1998). Life history strategies of green lacewings in temperate climates: a review (Neuroptera, Chrysopidae). In: Neuropterology 1997 (Proceedings of the 6th International Symposium on Neuropterology). Acta Zoological Fennica 209: 65-74.

Cappellozza, L. and Miotto, F. (1975). *Pseudodendrothrips mori* (Niwa) (Thysanoptera, Terebrantia) a species new to the Italian fauna. Redia G Zool 56: 387-389.

Carter D. J. (1984). Pest Lepidoptera of Europe with special reference to the British Isles. Dr. W. Junk, Dordrecht, Netherlands.

Cartwright, B. and Browning, H.W. (2003). Scales. Texas Citrus – Rootstock and scion varieties. Texas Agricultural Extension Service. http://aggie-horticulture.tamu.edu/citrus/12310.htm

Castagnoli, M. (1984). Contribution to the knowledge of the tydeids (Acarina: Tydeidae) of cultivated plants in Italy. Redia 47: 307-322.

Cayrol, R.A. (1972). Famille des Noctuidae. Sous-famille des Melicleptriinae. *Helicoverpa armigera* Hb, pp 1431-1441. In: Balachowsky, A.S., (ed) Entomologie appliquée à l'agriculture Vol. 2. Masson et Cie, Paris, France.

Ceparano, G and Job, S. (1996) Flucycloxuron: a new acaricide. Informatore Fitopatologico 46: 32-34.

Chararas, C. and Balachowsky, A.S. (1962). Family Bostrichidae, pp 304-315. In: Entomologie Appliquée a L'Agriculture. Tome I. Coléoptères (premier volume). Masson et Cie, Paris, France.

Chepurnaya, V.I. and Rybalov, L.N. (1981). The rose leaf roller on black currant. Zashchita Rastenii 4: 54.

Childers, C. C. and D. S. Achor. (1995). Thrips feeding and oviposition injuries to economic plants, subsequent damage, and host responses to infestation, pp 31 – 51. In: Parker, A.S, Skinner M. and Lewis, T. (eds) Thrips Biology and Management. Plenum, New York.

Childers, C.C. (1994). Feeding Injury to ‘Robinson’ Tangerine Leaves by *Brevipalpus* mites (Acari: Tenuipalpidae) in Florida and Evaluation of Chemical Control on Citrus. Florida Entomologist Online, vol. 77, no. 2. http://www.fcla.edu/FlaEnt/fe77p265.pdf

Ciampolini, M. and Maiulini, C. (1991). Damage to apple trees caused by carpophagous nitidulids. Informatore Agrario 47: 89-92.

Ciampolini, M., Rota, P.A., Marsala, P. and Brutto, A. (1985). A mite unjustly suspected of damaging citrus. Informatore Agrario 41: 71-73.

Ciccarone, A. (1957). *Elsinoë australis* Bitancourt et Jenkins, causing a citrus scab in Sicily. Rivista di Agrumicoltura 2: 1-36.

Clements, D.R. and Harmsen, R. (1990). Predatory behaviour and prey-stages preferences of stigmaeid and phytoseiid mites and their potential compatibility in biological control. Canadian Entomology 122: 321-328.

Colombo, M. and Limonta, L. (2001). Anoplophora malasiaca Thompson (Coleoptera: Cerambycidae) in Europe. Bollettino di Zoologia Agraria e di Bachicoltura 33: 65-68.

Conti, F., Tumminelli, R., Amico, C., Fisicaro, R., Perrotta, G. and Marullo, R. (2002). Monitoring *Pezothrips kellyanus* on citrus in eastern Sicily, pp 207-210. Thrips and tospovirus: Proceedings on the 7Th International Symposium on Thysanoptera.

Cook, W.C. (1941). The beet leafhopper. Farmers' Bulletin 1886. United States Government Printing Office, Washington, DC.

Croft, B.A. (1994). Biological control of apple rust mites by a phytoseiid mite complex and *Zetzellia mali* (Acari: Stigmaeidae), long term effects and impact of azinphosmethyl on colonization by *Amblyseius andersoni* (Acari: Phytoseiidae). Environmental Entomology 23: 1317-1325.

Croft, B.A. and MacRae, I.V. (1993). Biological control of apple mites by a phytoseiid mite complex and *Zetzellia mali* (Acari: Stigmaeidae) on *Typhlodromus pyri* and *Metaseiulus occidentalis* (Acari: Phytoseiidae). Environmental Entomology 22: 865-873.

Croft, B.A., McMurtry, J.A., and Luh, H.K. (1998). Do literature records of predation reflect food specialization and predation types among phytoseiid mites (Acari: Phytoseiidae). Experimental and Applied Acarology 22: 467-480.

Davidson, J.A. and Miller, D.R. (1990). Ornamental plants, pp. 603-632. In: Rosen, D. (ed.) Armoured Scale Insects, their Biology, Natural Enemies and Control. Vol. 4B. Elsevier, Amsterdam, Netherlands.

Davidson, R.H. and Lyon, W.F. (1987). Insect pests of farm, garden, and orchard. John Wiley & Sons, New York, USA. xiii + 640pp.

Davino, M., Areddia, R., and Polizzi, G. (1988). Citrus Tristeza in Italy, pp 1367-1370. Proceedings of the Sixth International Citrus Congress, Tel Aviv, Israel.

Davino, M., Catara, A., Russo, F., Terranova, G. and Carbone, G. (1984). A survey for citrus tristeza in Italy by the use of Enzyme-linked Immunosorbent Assay, pp 66-69. Proceedings of 9Th IOCV Conference, Riverside, USA.

Davino, M., Marras, F., Russo, F., Catara, A., Foddai, A., and Terranova, G. (1986). Present status of citrus tristeza in Italy, pp 8-13. Proceedings of 10Th IOCV Conference, Valencia, Italy.

Davis, P.R., Van Schagen, J.J., Widmar, M.A. and Craven, T.J. (1997). Assessment of the molluscicidal activity of a copper complex compound. In: Slug and snail pests in agriculture. Proceedings of Symposium, University of Kent.

Dogan, D. (1983). Pest Slugs and Snails. Biology and Control. (Translated by Sheila Gruber.). Springer-Verlag, Berlin, Heidelberg, New York.

Duso, C., Pasqualetto, C., Camporese, P. (1991). Role of the predatory mites Amblyseius aberrans (Oud.), Typhlodromus pyri Scheuten and Amblyseius andersoni (Chant) [Acari: Phytoseiidae] in vineyards. II. Minimum releases of A. aberrans and T. pyri to control spider mites populations. Journal of Applied Entomology 112: 298-308.

EPPO, 2004. PQR database (version 4.2). European and Mediterranean Plant Protection Organization, Paris, France.

Ezzat, Y.M. (1956). Studies on the "Kew Bug" *Orthezia insignis* Browne [Coccoidea - Ortheziidae]. Bulletin Société Entomologique d'Egypte 40: 415-431.

Fan, Q.H., Walter, D.E. and Proctor, H.C. (2003). A review of the genus *Ledermuelleriopsis* Willaman (Acari: Prostigmata: Stigmaeidae). Invertebrate Systematics 17: 551-574.

Farr, D.F., Bills, G.F., Chamuris, G.P. and Rossman, A.Y. (1989). Fungi on plant and plant products in the United States. The American Phytopathological Society Press, St. Paul, Minnesota, USA.

Fasulo, T.R. (1999). Citrus whitefly, *Dialeurodes citri* (Ashmead) [Insecta: Homoptera: Aleyrodidae]. University of Florida, Department of Entomology and Nematology, Florida Department of Agriculture and Consumer Services, Division of Plant Industry. EENT – 84.

Fasulo, T.R. and Brooks, R.F. (2001). Scale pests of Florida citrus. Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Fact Sheet ENY-814.

Fawcett, H.S. (1929). *Nematospora* on pomegranates, citrus and cotton in California. Phytopathology 19: 479-482.

Ferragut, F., Laborda, R., Costa-Comelles, J. and García-Marí, F. (1992). Feeding Behaviour of *Euseius stipulatus* and *Typhlodromus phialatus* on the Citrus Red Mite *Panonychus citri* [Acari: Phytoseiidae, Tetranychidae]. Entomophaga 37: 537-544.

Fletcher, B.S. (1989). Ecology; movements of tephritid fruit flies, pp 209-219. In: Robinson, A.S. and Hooper, G. (eds). Fruit Flies; Their Biology, Natural Enemies and Control. World Crop Pests, 3(B). Elsevier, Amsterdam, Netherlands.

Frank, J.H. and Mizell, R.F. (2004). Ladybirds, ladybird beetles, lady beetles, lady bugs of Florida, Coleoptera: Coccinellidae. University of Florida. Department of Entomology and Nematology. Florida Department of Agriculture and Consumer Services. Division of Plant Industry. EENY – 170.

Fraser, L.R. and Broadbent, P. (1979). Virus and related diseases of citrus in New South Wales. Biological and Chemical Research Institute, New South Wales Department of Agriculture, Rydalmere. Surrey Beatty & Sons P/L, Chipping Norton, NSW. 77 pp.

Froberg, L., Solhoy, T., Baur, A. and Baur, B. (2003). Lichen specificity of Oribatid mites (Acari: Oribatida) on limestone walls in the Great Alvar of Oland, Sweden. Entomologist Tidskrift 124: 177-182.

Frost, W.E. and Bailey, P. (1997). Identifying Mites on Inland Australian Citrus. A Colour Guide for Growers, Packers and Quarantine Staff. South Australian Research and Development Institute, Adelaide. 8 pp.

Futch, S.H., McCoy, C.W. and Childers, C.C. (2001). A guide to scale insect identification. Department of Entomology and Nematology, Florida Cooperative Extension Services, Institute of Food and Agricultural Sciences, University of Florida. Fact Sheet HS 817.

Garrido, A. and Ventura, J.J. (1993). Plagas de los cítricos. Bases para el manejo integrado. M.A.P.A., Madrid, Spain.

Gerson, U. (1994). The Australian Cheyletidae (Acari: Prostigmata). Invertebrate Systematics 8: 435-447.

Gerson, U. and Smiley, R.L. (1990). Acarina Biocontrol Agents, An illustrated Key and Manual. Chapman and Hall, London.

Giudice, V, Lo, and Lanza, G. (1973). The occurrence of *Sheraphelenchus entomophagus* on orange fruit. Informatore Fitopatologico 23: 15-16.

Grafton-Cardwell, Urena, A. and Morse, J. (2005). Recognizing bean thrips and other thrips inhibiting citrus. http://citrusent.uckac.edu/beanthripsbrochure.pdf

Graham M.B. and Gatter, D.G. (1990). Mass release and monitoring of *Phytoseiulus persimilis* in strawberries. Internal report, Agriculture Western Australia.

Graham, J.H. and Timmer, L.W. (2004). 2005 Florida Citrus Pest Management Guide: Brown rot of fruit. http://edis.ifas.ufl.edu/CG022

Green, E.E. (1922). The Coccidae of Ceylon, pp 347-472. Part V. Dulou & Co, London, UK.

Grimes, E.W. and Cone, W.W. (1985). Life history, sex attraction, mating, and natural enemies of the grape mealybug, *Pseudococcus maritimus* (Homoptera: Pseudococcidae). Annals of the Entomological Society of America 78: 554-558.

Hadidi, A., Flores, R., Randles, J.W. and Semancik, J.S. (2003). Viroids. CSIRO Publishing, Collingwood, Victoria.

Hagvar, S. and Kjondal, B.R. (1981). Succession, diversity and feeding habits of microarthropods in decomposing birch leaves. Pedobiologia 22: 386-408.

Halliday, B. (1998). Mites of Australia; A checklist and bibliography. Monographs on Invertebrate Taxonomy Vol. 5. CSIRO Publishing.

Halliday, B., Walter D.E., and Lindquist, E.E. (2004). Revision of the Australian Ascidae (Acarina: Mesostigmata. http://www.publish.csiro.au/nid/120/paper/IT96029.htm

Hamon, A.B. (2001). Whitefly of citrus in Florida. Florida Department of Agriculture and Consumer Service, Division of Plant Industry, Gainesville, Florida, USA. http://www.doacs.state.fl.us/~pi/enpp/ento/whitefly.htm

Hashem, A.G., Tadros, A.W. and Abo-Sheasha, M.A. (1997). Monitoring the honeydew moth, *Cryptoblabes gnidiella* Mill. In citrus, mango, and grapevine orchards (Lepidoptera: Pyralidae). Annals of Agricultural Science Cairo 42: 335-343.

Hely, P.C., Pasfield, G. and Gellatley, J.G (1982). Insect pests of fruit and vegetables in NSW. Inkata Press, Melbourne.

Hoddle, M.S. (1999). The biology and management of the avocado thrips, *Scirtothrips perseae* Nakahara (Thysanoptera: Thripidae). http://www.biocontrol.ucr.edu/avocadothrips.html

Hodgson, C.J. and Henderson, R.C. (2000). Coccidae (Insecta: Hemiptera: Coccoidae). Fauna of New Zealand number 41. Manaaki Whenua Press, Lincoln, Canterbury, New Zealand.

Hoffmann, M.P. and Frodsham, A.C. (1993) Natural Enemies of Vegetable Insect Pests. Cooperative Extension, Cornell University, Ithaca, NY. 63 pp.

Holm, E. and Wallace, M.M.H. (1989). Distribution of some Anystid Mites (Acari: Anystidae) in Australia and Indonesia and their Role as Possible Predators of the Cattle Tick, *Boophilis microplus* (Acari: Ixodidae). Experimental and Applied Acarology 6: 77-83.

Hoo, C.R., Coudriet, D.L. and Vail, P.V. (1984). *Trichoplusia ni* (Lepidoptera: Noctuidae) larval development on wild and cultivated plants. Environmental Entomology 13: 843-846.

Howarth, F.G. (1991). Environmental impacts of classical biological control. Annual Review of Entomology 36: 485-510.

Howitt, A.H. (2001). Grape mealybug. Fruit IPM Fact sheet. Michigan State University Extension. http://www.msue.msu.edu/vanburen/fgmbug.htm

HYPPZ (2003). Palm scale: *Chrysomphalus dictyospermi* Morgan [Insecta: Homoptera: Diaspididae]. http://www.inra.fr/Internet/Produits/HYPPZ/RAVAGEUR/6chrdic.htm

HYPPZ (2004). Mediterranean climbing cutworm: *Spodoptera littoralis* (Boisduval): http://www.inra.fr/Internet/Produits/

Ibrahim, S.S. and Shahateh, W.A. (1984). Biological studies on the citrus flower moth *Prays citri* Miller in Egypt. Arab Journal of Plant Protection 2: 4-9.

ICDB (2002). Insect Collection Database or Insect Reference Collection. Department of Agriculture, Government of Western Australia.

Inserra, S., Calabretta, C. and Garzia, G.T. (1987). Attack by *Cacoecimorpha pronubana* (Hübner) on protected crops of gerbera and rose and possibilities of chemical and biological control. Difesa delle Piante 10: 97-100.

James, D.G., Faulder, R.J. and Bartelt, R.J. (1995). Fauna and seasonal abundance of *Carpophilus* spp. (Coleoptera: Nitidulidae) in four stone fruit growing regions of south-eastern Australia as determined by pheromone-trapping. Journal of the Australian Entomological Society 34: 327-333.

James, D.G., Faulder, R.J., Vogel, B. and Moore, C.J. (2000). Pheromone-trapping of *Carpophilus* spp. (Coleoptera: Nitidulidae): fauna, abundance and seasonality in some Australian horticultural regions. Plant Protection Quarterly 15: 57-61.

Jeppson, L.R., Keifer, H.H. and Baker, E.W. (1975). Mites Injurious to Economic Plants. University of California Press, Berkeley, USA.

Jiang, H., and Gu, H.G. (1988). The bionomics of *Ceroplastes japonicus* Green and its parasitoids. Insect Knowledge 25: 154.

Kain, D.P. and Kovach, J. (2001). New York State Integrated Pest Management Program. Fact sheet. Phytophagous mirid bugs. /http://www.nysipm.cornell.edu/

Kajiwara, T., Umeya, K. and Asakawa, M. (1986). Handbook of Crop Diseases and Pests. Yokendo, Tokyo, Japan.

Karg, W. (1971). Investigations on the mite fauna of apple orchards with reference to the transition from standard spray programs to integrated treatment measures. Archiv fur Pflanzenschutz 7:243-279.

Karsholt, O. (1996). The Lepidoptera of Europe: A Distributional Checklist. Apollo Books, Stenstrup, Denmark.

Kielczewski, B. and Seniczak, S. (1972). The development cycle of the predatory mite *Colvolia faxini* (Tyroglyphidae, Acarina). Prace Komisji Nauk Rolniczych I Komisji Nauk Lesnych 34: 83-88.

Kim, J., Qin, T. and Lindquist, E.E. (1987). Description of *Tarsonemus parawaitei*, a new species of Tarsonemidae (Acari: Heterostigmata) associated with orchard and ornamental plants in Europe, Australia and New Zealand. Special Publications. Systematic and Applied Acarology 2: 1-28.

Klein, M., Rasooly, P. and Raccah, B. (1988). New findings on the transmission of *Spiroplasma citri*, the citrus stubborn disease agent in Israel, by a beet leafhopper from the Jordan Valley. Hassadeh 68: 1736-1737.

Klotz, J.H., Mangold, J.R., Vail, K.M., Davis, L.R. and Patterson, R.S. (1995). A survey of the urban pest ants (Hymenoptera: Formicidae) of peninsular Florida. Florida Entomologist 78: 109- 118.

Knapp, J.L. (1998). The Mediterranean fruit fly. Entomology and Nematology. Department Florida Cooperative Extension Services, Institute of Food and Agricultural Sciences, University of Florida. Fact Sheet ENY-809.

Kojima, K. and Nakamura, S. (1986). Food plants of Cerambycid beetles (Cerambycidae, Coleoptera) in Japan, pp 128-133. Hiba Society of Natural History, Shobara, Japan.

Komlovsky, I. and Jenser, G. (1992). Little Known Predatory Mite Species of Hungary (Acari: Stigmaeidae). *Acta Phytopathologica et* Entmologica Hungarica 27: 361-363.

Korah, S.M. and Osman, A.A. (1978). The tarsonemid mites under certain field crops in Menoufia Governorate, Egypt. Bulletin Société Entomologique d'Egypte 62: 191-196.

Krishnamoorthy, A. and Rajagopal, D. (1999). Record of predatory mite, *Eryngiopus* sp. on *Aonidiella aurantii* (Maskell). Insect Environment 5: 92.

Laviola, C. and Scarito, G. (1989). Distance and direction of dissemination of *Phoma tracheiphila* (Petri) Kantachveli et Gikachvili propagules. Phytopathologia Mediterranea 28: 161-163.

Lawrence, J.F and Britton, E.B. (1991). 'Coleoptera', pp 543-630. In: Naumann, I.D., Carne, P.B., Lawrence, J.F., Nielsen, E.S., Spradbury, J.P., Taylor, R.W., Whitten, M.J. & Littlejohn, M.J. (eds.) The Insects of Australia. Melbourne University Press, Carlton.

Lebrun, P., Jacques, J.M., Goossens, M. and Wauthy, G. (1978). The effect of interaction between the concentration of SO_2 and the relative humidity of air on the survival of the bark-living bio-indicator mite *Humerobates rostrolamellatus*. Water Air and Soil Pollution 10: 269-275.

Lewis, T. (1997). Thrips as crop pests. CABI International, Wallingford, UK. 740 pp.

Lin, J. and Zhang, Z.Q. (2001). Tarsonemidae of the World (Acari: Prostigmata). Key to Genera, geographical distribution, systematic catalogue and annotated bibliography. Systematic and Applied Acarology Society, London. 440 pp.

Liotta, G. (1975). Secondary effects of the most common phytosanitary products used against citrus Diaspididae in Sicily, on *Aphytis chilensis*. Fruits 30: 275 - 279.

Longo, S. (1986). Thrips on citrus groves, pp 121-125. In: Integrated pest control in citrus groves. Cavalloro, R. and Martino, E.D. (eds). Proceedings of the expert's meeting, Acireale, 26-29 March 1985. Balkema, A.A., Boston Publishers, Totterdam.

Longo, S. (1992). An occasional pest of citrus: *Charaxes jasius*. Informatore Agrario 48: 69-71.

MacRae, I.V. and Croft, B.A. (1996). Differential impact of egg predation by *Zetzellia mali* (Acari: Stigmaeidae) on *Metaseiulus occidentalis* and *Typhlodromus pyri* (Acri: Phytoseiidae). Experimental and Applied Acarology 20: 143-154.

Malfitano, M., Barone, M. and Alioto, D. (2005). A survey of citrus viroids in Campania (Southern Italy). Plant Disease 89: 434.

Martin, J.H. (1987). An identification to common whitefly pest species of the world (Homoptera: Aleyrodidae). Tropical Pest Management 33: 298-322.

Martin, J.H. (1999). The whitefly fauna of Australia (Sternorrhyncha: Aleyrodidae): a taxonomic account and identification guide. CSIRO Entomology Technical Paper No. 38. CSIRO, Canberra, Australia.

Marullo, R. (2002). Impact of imported pest thrips on the indigenous natural history and agricultural systems of southern Italy. Thrips and topsoviruses, pp 285-288. Proceedings of the 7Th International Symposium on Thysanoptera.

Massonie, G., Garnier, M. and Bové, J.M. (1976). Transmission of Indian citrus decline by *Trioza erytreae* (Del Guercio), the vector of South African greening, pp 18-20. In: Calavan, E.C. (ed.) Proceedings of the Seventh Conference of the International Organization of Citrus Virologists. University of California, Riverside, USA.

Mau, R.F.L. and Kessing, J.L.M (1992). *Pulvinaria psidii* (Maskell). Crop Knowledge Master. http://www.extento.hawaii.edu/kbase/crop/Type/p_psidii.htm

Mau, R.F.L. and Kessing, J.L.M. (1991). *Peridroma saucia* (Hübner). Crop Knowledge Master. http://www.extento.hawaii.edu/kbase/crop/Type/peridroma.htm

McLaren, G.F., Grandison, G., Wood, G.A., Tate, G. and Horner, I. (1999). Summer fruit in New Zealand; Management of pests and diseases. HortResearch AGMARDT/Summer fruit New Zealand Inc., University of Otago Press.

McLeod, R., Reay, F. and Smyth, J. (1994). Plant Nematodes of Australia Listed by Plant and by Genus. NSW Agriculture and Rural Industries Research and Development Corporation, Sydney.

McMurtry, J.A. (1992). Dynamics and potential impact of 'generalist' phytoseiids in agro ecosystems and possibilities for establishment of exotic species. Experimental and Applied Acarology 14: 371-382.

McMurtry, J.A. and Croft, B.A. (1997). Life styles of phytoseiid mites and their role as biological control agents. Annual Review of Entomology 42: 291-321.

Mehrnejad, M.R. and Ueckermann, E.A. (Mites (Arthropoda: Acari) associated with pistachio trees (Anacardiaceae) in Iran – I. Systematic and Applied Acarology Special Publications 6: 1-12.

Melía, A. (1993). Population development of *Toxoptera aurantii* (Boyer de Fonscolombe) (Homoptera: Aphididae) in the last fifteen years and their relation to the appearance of *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Aphididae). Boletín de Sanidad Vegetal Plagas 19: 609-617.

Mel'nik, V.A., Braun, U. and Hagedorn, G. (Eds.) (2000). Key to the fungi of the genus Ascochyta Lib. (Coelomycetes) (Revised and Translated Edn.). Parey Buchverlag Berlin, Berlin. Mel'nik, V.A., Braun, U. and Hagedorn, G. (Eds.) (2000). Key to the fungi of the genus Ascochyta Lib. (Coelomycetes) (Revised and Translated Edn.). Parey Buchverlag Berlin, Berlin.

Mendel, Z. and Gerson, U. (1982). Is the mite *Lorryia formosa* Cooreman (Prostigmata: Tydeidae) a sanitising agent in citrus groves? Acta Ecologica. Applic 3: 47-51.

Michael, P. and Carmody, P. (2002). Management of canola pests. In: Management of false wireworms and other new seedling pests of canola. Michael, P.J., Project Supervisor. GRDC Project DAW612.

Mijuskovic, M. and Kosac, D. (1972). Control of *Aculops pelekassi* Keifer (Acari: Eriophyidae), an important mite injurious to citrus on the coast of Montenegro. Jugoslovenskog Vocarstva 21-22: 835-845.

Milne, D.L. (1977). Biological control of citrus thrips, *Scirtothrips aurantii*: what are the prospects? Citrus and Subtropical Fruit Journal 528: 14.

Mineo, G. (1986). On citrus trees Lepidoptera and particularly on those inhibiting the Mediterranean area, pp 127 – 133. In: Integrated pest control in citrus groves. Cavalloro, R. and Martino, E.D. (eds.). Proceedings of the expert’s meeting, Acireale, 26-29 March 1985. Balkema, A.A., Boston Publishers, Totterdam.

Mineo, G. and Viggiani, G. (1976). On the acclimatisation in Italy of *Leptomastix dactilopii*, a parasite of the Citrus mealybug. Informatore Fitopatologico 26: 13-15.

Mineo, G., Mirabello, E., and Viggiani, G. (1980). Catches of adults of *Prays citri* Mill. (Lepidoptera: Plutellidae) with pheromone traps and progress of infestations in lemon groves in eastern Sicily. Bollettino del Laboratorio di Entomologia Agraria 'Filippo Silvestri', Portici 37: 177-197.

Mitomi, M., Kuroda, E. and Okamoto, H. (1990). Ecological study of the white-spotted longicorn beetle, *Anoplophora malasiaca* Thomson (Coleoptera: Cerambycidae). I. Investigation of adult emergence holes in citrus orchards in Kagawa Prefecture. Japanese Journal of Applied Entomology and Zoology 34: 7-13.

Morris, R.F. (1976). Relation of parasite attack to the colonial habit of *Hyphantria cunea*. Canadian Entomologist 108: 833-836.

Mound, L. (2004). Thysanoptera of Australia. http://www.ento.csiro.au/thysanoptera/Ozthrips/ThripDendrothripinae.htm

Mound, L. A., and Teulon, D. A. J. (1995). Thysanoptera as phytophagous opportunist, pp 3 –19. In: Parker, B.L., Skinner, M. and Lewis, T. (eds), Thrips Biology and Management. Plenum, New York.

Mound, L.A. and Gillespie, P. (1997). Identification Guide to Thrips Associated with Crops in Australia. NSW Agriculture and CSIRO Entomology.

Mound, L.A. and Halsey, S.H. (1978). Whitefly of the world. A systematic catalogue of the Aleyrodidae (Homoptera) with host plant and natural enemy data. British Museum (Natural History) and Wiley, London.

Mphuru, A.N. (1974). *Araecerus fasciculatus*: A review. Tropical Stored Products Information 26:7-15.

Mukerji, K.G. (1968). *Nematospora gossypii*. CMI Descriptions of Fungi and Bacteria No. 185. Commonwealth Mycological Institute, Surrey, UK.

Mullen, G.R., Leprince, D.J., O'Conner, B.M. and Viraktamath, C.A. (1989). Acarina associates of horse flies and deer flies (Diptera: Tabanidae) in North America, pp 291-296. In: Channa-Basavanna, G.P. (ed.) Progress in Acarology Volume 2.

Muma, M.H., Zaher, M.A., Soliman, Z.R. and El-Bishlawy, S.M. (1975). Feeding habits of the predacious mite, *Cunaxa capreolus* (Acarina: Cunaxidae). Entomophaga 20: 209-212.

Naumann, I.D. (1991). Hymenoptera, pp 916-940. In: Naumann, I.D., Carne, P.B., Lawrence, J.F., Nielsen, E.S., Spradbury, J.P., Taylor, R.W., Whitten, M.J. and Littlejohn, M.J. (eds.). The Insects of Australia. Melbourne University Press, Carlton.

Nohara, K. (1962). Studies on the biology of *Unaspis yanonensis*. Science Bulletin of the Faculty of Agriculture Kyushu University, No. 20.

Nucifora, A. and Vacante, V. (2004). Citrus mites in Italy. VII. The family Tarsonemidae. Species collected and notes on ecology. Acarologia 44: 49-65.

O'Connell, T. and Bolger, T. (1997). Fungal fruiting bodies and the structure of fungus-—micro-arthropod assemblages. Biology and Environment. Proceedings of the Royal Irish Academy 3: 249-262.

O'Conner, B.M. (2001). Historical Ecology of the Acaridae (Acari): Phylogenetic Evidence for Host and Habitat Shifts, pp 76-82. Acarology: Proceedings of the 10th International Congress, Canberra, Australia. CSIRO Publishing, Collingwood, Victoria.

O'Dowd, D.J. (1994). Mite association with the leaf domatia of coffee (*Coffea arabica*) in north Queensland, Australia. Bulletin of Entomological Research 84: 361-366.

Oatman, E.R. (1973). An ecological study of arthropod populations on apple in northeastern Wisconsin: population dynamics of mite species on the foliage. Annals of the Entomological Society of America 66: 122-131.

Ohkubo, N. (1980). Ecology and control of the arrowhead scale, *Unaspis yanonensis* Kuwana. Review of Plant Protection Research 13: 1-11.

Pantaleoni, R.A. and Lepera, D. (1985) The Neuroptera of agricultural crops: investigations of chrysopids in citrus orchards in Calabria, pp 451-457. Atti XIV Congresso Nazionale Italiano di Entomologia sotto gli auspici dell'Accademia Nazionale Italiana di Entomologia, della Societa Entomologica Italiana e della International Union of Biological Sciences. Palermo - Erice - Bagheria, 28 maggio-1 giugno 1985.

Pellizzari, G. and Camporese, P. (1994). The Ceroplastes species (Homoptera: Coccoidea) of the Mediterranean Basin with emphasis on *C. japonicus* Green. Annales de la Societe Entomologique de France 30: 175-192.

Peres, N. A. R., Souza, N. L., Zitko, S. E. and Timmer, L. W. (2002). Activity of benomyl for control of postbloom fruit drop of citrus caused by *Colletotrichum acutatum*. Plant Disease 86: 620-624.

Perrotta, G. and Graniti, A. (1988). *Phoma tracheiphila* (Petri), Kantachveli et Gikachvili, pp 396-398. In: Smith, I.M., Dunez, J., Lelliot, R.A., Phillips, D.H. and Archer, S.A. (eds.) European Handbook of Plant Diseases. Blackwell Scientific Publications, Oxford, UK.

Ploetz, R.C., Lim, T.K., Menge, J.A., Kenneth, G., Rohrbach, K.G. and Michaolides, T.J. (2003). Common pathogens of tropical fruit crops, pp-19. In: Ploetz, R.C. (ed.) Diseases of Tropical Fruit Crops. Wallingford, UK: CABI Publishing.

Pretorius, M.C., Crous, P.W., Groenewald, J.Z. and Braun, U. (2003). Phylogeny of some cercosporoid fungi from Citrus. Sydowia, 55: 286-305.

Prokopenko, A.I. and Mokrousova, L.A. (1981). *Scutellista* against the Japanese wax scale. Zashchita Rastenii 12: 43.

QDPI (2002). Japanese bayberry whitefly. Animal and Plant Health, Queensland Department of Primary Industries, Brisbane. File No. APH0163 on Internet site www.dpi.qld.gov.au

Ragusa, S. (1981). Influence of different kinds of food substances on the developmental time in young stages of the predacious mite *Typhlodromus exhilaratus* Ragusa (Acarina: Phytoseiidae). Redia 64: 237-243.

Rakha, M.A. and McCoy, C.W. (1984). *Eryngiopus citri*, a new mite on Florida citrus with descriptions of the developmental stages (Stigmaeidae: Actinedida). Florida Entomology 67: 504-507.

Readshaw, J.L. (1975). The ecology of tetranychid mites in Australian orchards. Journal of Applied Ecology 12: 473-495.

Reitz, S.R., and Trumble, J.T. (2002). Competitive displacement among insects and arachnids. Annual Review of Entomology 47: 435-465.

Reuther, W., Calavan, E.C. and Carman, G.E. (1978). The citrus industry. Volume IV: Crop protection. University of California.

Reuther, W., Calavan, E.C. and Carman, G.E. (1989). The citrus industry. Crop protection, post harvest technology and early history of citrus research in California. Division of Agriculture and Natural Resources, University of California.

Roberts, P. and Guillebeau, P. (2000). Tobacco Flea Beetle - *Epitrix hirtipennis* (Melsheimer). Department of Entomology, College of Agriculture and Environmental Sciences, University of Georgia. http://www.gaipm.org/top50/tobaccoflea.html

Robinson, A. E., Inserra, R. N. E., Caswell-Chen, P. Vovlas, N. and Troccoli, A. (1997). *Rotylenchulus* species: identification, distribution, host ranges, and crop plant resistance. Nematropica 27: 127-180.

Rose, M., DeBach, P. and Woolley, J. (1981). Potential new citrus pest: Japanese bayberry whitefly. California Agriculture 35: 22-24.

Rosenheim, J. A., Welter, S. C. Johnson, M. W., Mau R. F. L. and Gusukuma-Minuto L. R. (1990). Direct Feeding Damage on Cucumber by Mixed-Species Infestations of *Thrips palmi* and *Frankliniella occidentalis* (Thysanoptera: Thripidae). Journal of Economic Entomology 83: 1519-1525.

Rotundo, G., Tremblaym, E. and Giacometti, R. (1979). Final results of mass captures of the citrophilus mealybug males (*Pseudococcus calceolariae* Mask.) (Homoptera Coccoidea) in a citrus grove. Bollettino del Laboratorio di Entomologia Agraria "Filippo Silvestri", Portici 36: 266-274.

Russell, R.C. (2001). The Medical Significance of Acari in Australia, pp 535-546. Acarology: Proceedings of the 10th International Congress, Canberra, Australia. CSIRO Publishing, Collingwood, Victoria.

Russo, F. (1956). La presenza del virus della tristeza su limone “Dwarf Meyer” e mandarino “Satsuma” riscontrata in Sicilia. Riv. Agrumicoltura 1: 281-289.

Sampo, A. (1977). The laurel psyllid (*Trioza alacris* Flor.). Floricultore 14: 4.

Santini, L. (1995). On the phytophagy of the European earwig *Forficula auricularia* L. in Italian orchards. In: IOBC-WPRS working group 'Integrated plant protection in stone fruit' held at Nimes, France, on 6-8 September 1994. Bulletin OILB SROP 18: 28-30.

Santos, M.A. and Laing, J.E. (1985). Stigmaeid predators, pp. 197-203. In: Helle, W. and Sabelis, M. W. (eds., Spider mites: Their biology, natural enemies and control. Vol 1B. Elsevier, Amsterdam.

Shivas, R.G. (1989). Fungal and bacterial diseases of plants in Western Australia. Journal of the Royal Society of Western Australia 72: 1-62.

Shivas, R.G., Smith, M.W., Marney, T.S., Newman, T.K., Hammelswang, D.L., Cooke, A.W., Pegg, K.G. and Pascoe, I.G. (2005). First record of *Nematospora coryli* in Australia and its association with dry rot of citrus. Australasian Plant Pathology 34: 99-101.

Siddiqi, M.R. 1986. *Xiphinema* index. C.I.H. Descriptions of Plant-parasitic Nematodes. Set 3, No. 45. Commonwealth Institute of Parasitology. C.A.B. International. 4 pp.

Silva, E.B. and Mexia, A. (1999). The pest complex *Cryptoblabes gnidiella* Mill (Lepidoptera: Pyralidae) and *Planococcus citri* (Risso) (Homoptera: Pseudococcidae) on sweet orange groves in Portugal: Interspecific association. Boletin de Sanidad Vegetal Plagas 25: 89-98.

Sinacori, A. and Mineo, N. (1997). Two new host plants of *Prays citri* and *Contarinia citri* (*Casimiroa edulis* - *Ligustrum lucidum* - Sicily). Informatore Fitopatologico 47: 13-15.

Sinacori, A., Mineo, G., Verde, G. Lo. (1992). Observations on *Aphanogmus steinitzi* Priesner (Hymenoptera: Ceraphronidae) parasitoid of *Conwentzia psociformis* (Curtis) (Neuroptera: Coniopterygidae). Phytophaga Palermo 4: 29-48.

Siscaro, G., Longo, S. and Ragusa, S. (1988). Notes on population dynamics of *Archips rosanus* (L.) and *Cacoecimorpha pronubana* (Hübner) in Sicilian citrus groves. Bulletin SROP 11: 32-38.

Smiley, R.L. (1975). A generic revision of the mites of the family Cunaxidae (Acarina). Annals of the Entomological Society of America 68: 227-244.

Smith, D., Beattie, G.A.C. and Broadley, R. (1997). Citrus pests and their natural enemies. Information series Q197030. Queensland Department of Primary Industries, Brisbane.

Smith, I.M., Lindquist, E.E. and Behan-Pelletier. V. (1998). Mites (Acari). In: Assessment of species diversity in the Montant Cordillera Ecozone, Smith, I.M. and Scrudder, G.G. (eds.), Ecological Monitoring and Assessment Network, Burlington. http://www.naturewatch.ca/eman/reports/publications/99_montane/mites/mites04.html.

Smrž, J. (1992). The ecology of the microarthropods community inhabiting the moss cover of roofs. Pedobiologica 36: 331-340.

Stary, P. and Carver, M. (1979) Two new species of *Aphidius* Nees (Hymenoptera: Ichneumonoidea: Aphidiidae) from Australia [*Aphidius pelargonii*, *Aphidius similis*]. Journal of the Australian Entomological Society 18: 337-341.

Stepanov, K.M. and Shaluishkina, V.I. (1952). Lemon fruit and seeds - sources of initial infectious desiccation. Microbiology Moscow 28: 48-51.

Stimmel, J.F. (1998). Wax scales, *Ceroplastes* spp. Homoptera: Coccidae. Pennsylvania Department of Agriculture, Bureau of Plant Industry, Entomology Circular No. 191.

Suski, Z.W. (1968). Polish mites of the family tarsonemidae (Acarina: Heterostigmata) *Tarsonemus idaeus* n.sp.. Bulletin of Polish Academy of Science 10: 637-642.

Teviotdale, B.L., Michailides, T.J. and Pscheidt, J.W. (2002). Compendium of nut crop diseases in temperate zones. The American Phytopathological Society, St. Paul, Minnesota.

Timmer, L.W., Garnsey, S.M. and Broadbent, P. (2003). Diseases of citrus. In: Ploetz, R.C. (ed.) Diseases of tropical fruit crops. CABI Publishing, UK.

Timmer, L.W., Garnsey, S.M. and Graham, J.H. (2000). Compendium of Citrus Diseases. 2nd Edition. The American Phytopathological Society Press, St. Paul, Minnesota, USA. 92 pp.

Timmer, L.W., Roberts, P.D. and Chung, K.P. (2002). 2003 Florida Citrus Pest Management Guide. Plant Pathology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. pp 147. http://edis.ifas.ufl.edu/TOPIC_BOOK_Florida_Citrus_Pest_Management_Guide

Tumminelli, R., Saraceno, F. and Conti, D. (1997). Ants in citrus groves. Informatore Agrario 53: 57-60.

Ueckermann, E.A. and Smith Meyer, M.K.P. (1979). African Tydeidae (Acari). I. The Genus *Lorryia* Oudemans, 1925. Phytophylactica 11: 43-50.

USDA (2005). Acari: Yellow Mites – Tydeidae. http://www.sel.barc.usda.gov/acari/content/tydeid1.html

Uygun N., Ohnesorge, B. and Ulusoy, R. (1990). Two species of whiteflies on citrus in Eastern Mediterranean: *Parabemisia myricae* (Kuwana) and *Dialeurodes citri* (Ashmead). Morphology, biology, host plants and control in southern Turkey. Journal of Applied Entomology 110: 471-482.

Vacante, V. (1989). Citrus mites in Italy. III. The Acarididi (Hemisarcoptidae Oudemans, Acaridae Ewing & Nesbitt, Saproglyphidae Oudemans and Glycyphagidae Berlese). Bollettino di Zoologia Agraria e di Bachicoltura 21: 45-84.

Vacante, V. and Gerson, U. (1987). Three species of *Eryngiopus* (Acari: Stigmaeidae) from Italy, with key to species and summary of habitats. Redia 70: 385-401.

Vacante, V. and Nucifora, A. (1986a). A first list of the mites in citrus orchards in Italy, pp 177-188. In: Cavalloro, R., and Di Martino, E. (eds.). Integrated Pest Control in Citrus-Groves: Proceedings of the experts' meeting, Acireale, 26-29 March 1985. Rotterdam, Netherlands: Published for the Commission of the European Community by A.A. Balkema, Rotterdam/Boston.

Vacante, V. and Nucifora, A. (1986b). Gli Acari degli agrumi in Italia. 1. Specie rinvenute e chiave per il riconoscimento degli ordini, dei sottordini e delle famiglie. Bollettino di Zoologia Agraria e di Bachicoltura 18: 115-166.

Vacante, V., Nucifora, A. and Garzia, G.T. (1988) Citrus mites in the Mediterranean area. Bulletin SROP 11: 39-49.

Van de Vrie, M. (1991). Tortricids in ornamental crops in greenhouses. In: Van der Geest, Evenhuis, (eds). Tortricoid Pests, their biology, natural enemies and control. World Crop Pests 5: 525-530.

Vulic, M. and Beltran, J.L. (1977). The whitefly *Aleurothrixus floccosus*, a serious pest of citrus crops. Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz 84: 202-214.

Walker, J., Tesoriero, L., Pascoe, I. and Forsberg, L.I. (1988). Basal rot of *Syngonium* cultivars and the first record of *Ceratocystis fimbriata* from Australia. Australasian Plant Pathology 17: 22-23.

Walter, D.E. and Shaw, M. (2002). First record of the mite *Hirstiella diolii* Baker (Prostigmata: Pterygosmatidae) from Australia, with a review of mites found on Australian lizards. Australian Journal of Entomology 41: 30-34.

Waterhouse, D.F. and Sands, D.P.A. (2001). Classical Biological Control of Arthropods in Australia. ACIAR Monograph No. 77. Canberra, Australia. Australian Centre for International Agricultural Research. 560 pp. http://pandora.nla.gov.au/pan/24768/20020520/www.aciar.gov.au/publications/monographs/77/index.htm

Watkins, G.M. (1981). Compendium of Cotton Diseases. The American Phytopathological Society, St. Paul, Minnesota.

Watson, G.W. (2004). Verification of Yellow scale *Aonidiella citrina* (Coquillett) [Hemiptera: Diaspididae], Forrestfield, on upper surface of Citrus sp. leaf, 13.ii.1990, coll. J.H. Martin no. 5651. Personal communication. Scientific Associate (Sternorrhyncha - Coccoidea and Aleyrodoidea) Entomology Department, The Natural History Museum, Cromwell Road, London SW7 5BD, UK. Personal Communication, Perth.

Weeden, C.R., Shelton, A.M., Li, Y. and Hoffmann, M.P. (2005). Biological control: A guide to natural enemies in North America. Cornell University. http://www.nysaes.cornell.edu/ent/biocontrol/

Whitney, J. and James, D.G (1996). The Phytoseiid fauna of grapevines in Australia. International Journal of Acarology 22: 279-284.

Wikipedia (2004). *Tapinoma erraticum*. http://en.wikipedia.org/wiki/Erratic_ant

Williams, A. (2001). Agricultural pests and beneficials of the Kimberley. Bulletin 4494. Department of Agriculture, Government of Western Australia.

Wilson, C.G. (1991). Notes on *Phyllocnistis citrella* Stainton (Lepidoptera: Phyllocnistidae) attacking four citrus varieties in Darwin. Journal of Australian Entomological Society 30: 77-78.

Wilson, S.W. and McPherson, J.E. (1981). Life histories of *Anormenis septentrionalis*, *Metcalfa pruinosa*, and *Ormenoides venusta* with descriptions of immature stages. Annals of the Entomological Society of America 74: 299-311.

Woods, W. (2005). Confirming the introduction in 1995 of the citrus leaf miner parasite *Ageniaspis citricola* [Hymenoptera: Encyrtidae] in Western Australia.

Woods, W., Dick, J. and Learmonth, S. (1996). Orchard and Vineyard pest and disease management guide, March 1996. Agriculture Western Australia Bulletin 4313.

Wysoki, M., Yehuda, S.B. and Rosen, D. (1993). Reproductive behaviour of the honeydew moth *Cryptoblabes gnidiella*. Invertebrate Reproduction and Development 24: 217-224.

Young, C. (1996). Metal chelates as stomach poison molluscicides for introduced pests, *Helix aspersa*, *Theba pisana*, *Cernuella virgata* and *Deroceras reticulatum* in Australia. In: Henderson, I.F. (ed) Slug and Snail Pests in Agriculture. British Crop Protection Council, Farnham, UK.

Zanardi, D., Loche, P. and Fresu, B. (1979). *Rhizotogus rugifrons*, a new pest of citrus in Sardinia. Informatore Agrario 35: 5427-5428.

Zangheri, S. and Donadini, P. (1980). Appearance in the Venice district of a Nearctic bug: *Metcalfa pruinosa* Say (Homoptera, Flatidae). Redia 63: 301-305.

Appendix – 2: DATA SHEETS FOR QUARANTINE PESTS

2.1 ARTHROPODS

2.1.1 Pink citrus rust mite

Aculops pelekassi (Keifer) [Acari: Eriophyidae] - pink citrus rust mite; Japanese citrus rust mite.

Synonym(s): *Aculus pelekassi* (Keifer).

Host(s): *Citrus* spp.; *Citrus reticulata* (clementine, mandarin, tangerine); *Citrus sinensis* (navel orange, sweet orange, Valencia orange).

Distribution: Italy (Benfatto, 1980); Japan (Matsumoto *et al*., 1983); Taiwan (Huang & Wang, 1997); United States (Childers *et al*., 2004); and Thailand and Brazil (Ashihara *et al*., 2004).

Biology: The pink citrus rust mite (PCRM) is found on all citrus varieties throughout Florida and is an important pest of fruit grown for the fresh market (Childers *et al*., 2004). Since citrus is a perennial plant that flushes continuously in subtropical and tropical regions of the world, eriophyid mites can move within the tree from mature senescing plant parts to newly formed leaves and stems and subsequently to mature fruit. PCRM migrates to newly formed stem growth and the under surface of leaves before moving to the upper surface of leaves and subsequently to the fruit (Seki, 1981). The distribution of PCRM in citrus trees and on individual fruit suggests it avoids exposure to solar radiation (Pena & Baranowski, 1990; Hall *et al*., 1991). The mites congregate at leaf edges and so are easily distributed by wind.

On the favoured areas of host plants, mites wander randomly, usually feeding on a single epidermal cell for a short time before retracting their stylets, briefly searching for a new feeding site and then feeding again. Within a short time, extensive probing of the surface of leaves and fruit causes destruction of masses of epidermal cells. Injuries to the upper leaf surface are confined to epidermal cells and appear as slightly rough brownish to black patches. PCRM not only causes russeting of leaves but also causes mild to severe distortion of new growth, mesophyll collapse, chlorosis and leaf drop (Burditt & Reed, 1963; Jeppson *et al*., 1975).

PCRM has four developmental stages during its life cycle: egg, first instar (larva), second instar (nymph) and adult (Childers *et al*., 2004). Egg deposition begins within two days of the female reaching sexual maturity and continues throughout her life of 14 to 20 days. Eggs are laid singly or in clusters on the surface of leaves, fruit and green twigs (Childers *et al*., 2004). The female lays one to two translucent white eggs per day and up to 30 during her lifetime. Eggs hatch in about 3 days at 24.5^{o}C. The newly hatched nymphs resemble the adults, changing in colour from clear to lemon yellow or pink after commencing to feed. After about 2 days at 24.5^{o}C, moulting occurs. Males and females have an average life span of 6 and 14 days respectively at 24.5^{o}C (Childers *et al*., 2004). In the field, females can live nearly 30 days in the winter.

Economic importance: PCRM affects fruit quality when infestations are high. The primary effect of fruit damage caused by PCRM is cosmetic, resulting in lower grade standards (Tono *et al*., 1978). Reduced fruit size, increased water loss and increased fruit drop have been associated with severe injury to fruit.

References:

Ashihara, W., Kondo, A., Shibao, M., Tanaka, H., Hiehata, K. and Izumi, K. (2004). Ecology and control of eriophyid mites injurious to fruit trees in Japan. JARQ 38: 31-41. http://www.jircas.affrc.go.jp

Benfatto, D. (1980). The principal citrus mites and their control. Frutticoltura 42: 43-54.

Burditt, A.K., Jr. and Reed, D.K. (1963). Damage caused by *Aculops pelekassi* Keifer, a rust mite of citrus. Proceedings of Florida State Horticultural Society 76: 41-47.

Childers, C.C., Hall, D.G., Knapp, J.L., McCoy, C.W., Rogers, J.S. and Stansly, P.A. (2004). 2005 Florida citrus pest management guide: Citrus rust mites. Department of Entomology and Nematology, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Publication No. ENY-603.

Hall, D.G., Childers, C.C. and Egar, J.E. (1991). Estimating citrus rust mite (Acari: Eriophyidae) levels on fruit in individual citrus trees. Environmental Entomology 20: 383-390.

Huang, T. and Wang, C.F. (1997). A new-record species of eriophyid mite on lemon from Taiwan (Acarina: Eriophyidae). Chinese Journal of Entomology 17: 269-274.

Jeppson, L.R., Keifer, H.H. and Baker, E.W. (1975). Mites Injurious to Economic Plants. University of California Press, Berkeley, USA. 614 pp.

Matsumoto, K., Seki, M. and Matsumoto, K. (1983). Life cycle of the pink citrus mite, *Aculops pelekassi* (Keifer), in Japan. Proceedings of the International Society of Citriculture 2: 656-658.

Pena, J.E. and Baranowski, R.M. (1990). Dispersion indices and sampling plans for the broad mite (Acari: Tarsonemidae) and the citrus rust mite (Acari: Eriophyidae) on limes. Environmental Entomology 19: 378-382.

Seki, M. (1981). Life cycle of the pink citrus rust mite, *Aculops pelekassi* (Keifer), in Japan. Proceeding of the International Society of Citriculture. pp 656-658.

Tono, T., Fujita, S. and Yamaguchi, S. (1978). Effect of infestation by citrus rust mites, *Aculops pelekassi* (Keifer), on development of satsuma mandarin fruit and availability for juice processing from damaged fruit. Agricultural Bulletin, Saga University 44: 57-66.

2.1.2 Citrus red mite

Panonychus citri McGregor [Acari: Tetranychidae] – citrus red mite

Synonym(s): *Metatetranychus citri* Pritchard & Baker; *Panonychus mori* Yokoyama; *Paratetranychus citri* McGregor; *Tetranychus citri* McGregor.

Host(s): *Averrhoa carambola* (carambola); *Carica papaya* (papaw); *Citrus limon* (lemon); *Citrus reticulata* (mandarin); *Citrus sinensis* (navel orange); *Citrus unshiu* (satsuma); *Citrus* x *paradisi* (grapefruit); *Citrus* spp.; *Eriobotrya japonica* (loquat); *Fragaria*; *Ilex crenata* (box-leaved holly); *Malus domestica* (apple); *Manihot esculenta* (cassava); *Osmanthus fragrans*; *Prunus laurocerasus*; *Prunus persica* (peach); *Pyrus communis* (European pear); *Vitis vinifera* (grapevine); *Ziziphus mauritiana* (Chinese date).

Distribution: Reported in nearly all areas of the world where citrus is grown (Bolland *et al*., 1998). Argentina; Australia (New South Wales, Queensland); Azerbaijan; Bermuda; Brazil; Canada; Chile; China; Colombia; Costa Rica; Croatia; Cuba; France; Georgia; Greece; India; Iran; Israel; Italy; Japan; Korea; Lebanon; Malaysia; Mexico; Morocco;

Mozambique; New Zealand; Peru; South Africa; Spain; Sri Lanka; Tunisia; Turkey; USA (Alabama; Arizona; California; Florida; Georgia; Hawaii; Louisiana; Mississippi; North Carolina; Oregon; South Carolina; Texas); USSR; Venezuela; Vietnam; Yugoslavia (EPPO, 2004).

Biology: Adult *Panonychus citri* females lay two to four eggs per day for up to 3-4 weeks. Eggs are laid on the foliage and fruits and hatch into the larval stage after 1 week. The larvae migrate over the plant and begin feeding after the first moult. Nymphs and adults extract nutrients from the host tissue using their piercing, sucking mouthparts. Nymphs progress through two stages before becoming adults. Between each of these active stages, the nymph enters into an immobile stage while molting, during which it anchors itself to the leaf or to its webbing. Development times from egg to adult vary depending on temperature and humidity, with a mean development time of 10 days at 26°C and 70% relative humidity. Up to 16 generations may occur within one year, with the majority of these (10-11) occurring in spring and summer. This mite overwinters in all stages (Jeppson *et al*., 1975).

Adults and nymphs cause damage by feeding on host tissue. This produces tiny grey or silvery spots on leaves and fruit (stippling). Infestations on leaves are frequently greater than on fruit. Damage to leaves inhibits photosynthesis and can lead to necrosis. Severe infestations can lead to premature leaf fall, dieback and decreased vigour (Kranz *et al*., 1977; Davidson & Lyon, 1987).

Economic importance: *Panonychus citri* is considered to be an economically important and widespread pest of citrus crops (Jeppson *et al*., 1975). Peak infestations of this pest can vary greatly both within and between seasons (McMurtry *et al*., 1992). However, studies by Hare & Phillips (1992) and Hare *et al*. (1992) were unable to confirm the seriousness of attacks by this mite on foliage and subsequent economic losses. Following a detailed 4-year study of orange groves in California, USA, they concluded that infestations of up to 10 adult females per leaf could be tolerated without any significant economic loss, and without cumulative injury over four consecutive generations.

References:

Bolland, H.R., Gutierrez, J. and Flechtmannn, C.H.W. (1998). World catalogue of the spider mite family (Acari: Tetranychidae). pp. 392

Davidson, R.H. and Lyon, W.F. (1987). Insect pests of farm, garden, and orchard. John Wiley & Sons, New York, USA. xiii + 640 pp.

EPPO (2004). PQR database (version 4.2). European and Mediterranean Plant Protection Organization, Paris, France.

Hare, J.D., Pehrson, J.E., Clemens, T., Menge, J.A., Coggins, C.W.Jr., Embleton, T.W. and Meyer, J.L. (1992). Effect of citrus red mite (Acari: Tetranychidae) and cultural practices on total yield, fruit size, and crop value of 'Navel' orange: years 3 and 4. Journal of Economic Entomology 85: 486-495.

Hare, J.D. and Phillips, P.A. (1992). Economic effect of the citrus red mite (Acari: Tetranychidae) on southern California coastal lemons. Journal of Economic Entomology 85: 1926-1932.

Jeppson, L.R., Keifer, H.H. and Baker, E.W. (1975). Mites Injurious to Economic Plants. University of California Press, Berkeley, USA. 614 pp.

Kranz, J., Schmutterer, H. and Koch, W. (1977). Diseases, pests and weeds in tropical crops. Paul Parey, Berlin, Germany.

McMurtry, J.A., Morse, J.G. and Johnson, H.G. (1992). Studies of the impact of *Euseius* species (Acari: Phytoseiidae) on citrus mites using predator exclusion and predator release experiments. Experimental and Applied Acarology 15: 233-248.

2.1.3 Yellow mite

Species: *Lorryia formosa* Cooreman [Acari: Tydeidae] – Yellow mite

Synonym(s): *Tydeus formosa* Cooreman

Distribution: Italy (Vacante & Nucifera, 1986); Florida, Spain (Aguilar & Childers, 2000); Argentina; Brazil; Chile; Ecuador; Morocco; Portugal; and Uruguay (Jeppson *et al*., 1975).

Host (s): Wide host range including avocado (Jeppson *et al*., 1975); and citrus (Aguilar & Childers, 2000).

Biology: The family is difficult to characterise, although easy to recognise. Mating has not been observed so it is presumed that the males are spermatophore layers (Jeppson *et al*., 1975). Females of *Lorryia formosa* lay their eggs closer together vertically in two or three layers. The incubation period is 3 to 4 days and the life cycle lasts from 21 to 41 days. This mite congregates at the base of twigs, petioles and flowers and various rough areas on the branches (Jeppson *et al*., 1975).

In winter the mites congregate on top of the fruit stems and developing fruit. As mite colonies become denser in the spring, the mite settle on the lower part of the leaf near centre rib where larvae remain, but produce no injuries until the first moult. After moulting the mites abandon the leaves and move to the young fruit where females begin to lay eggs under sepals and fruit peduncles. There the mites are protected as they feed and produce injury to young fruit (Jeppson *et al*., 1975). *Lorryia formosa* is susceptible to sulfur sprays and dusts or to the specific acaricides used to control tetranychid mites. Organophosphorus and carbamate acaricides are not generally effective (Jeppson *et al*., 1975).

Economic importance: Most of the species are of no economic importance, probably feeding on fungi, honeydew etc. *Lorryia formosa* has been found damaging citrus (Jeppson *et al*., 1975). Injuries caused by *Lorryia formosa* results in a ring of dead brown tissue which enlarges as the fruit grows.

References:

Aguilar, H. and Childers, C.C. (2000). Tydeidae (Acari: Prostigmata) on Florida citrus, pp 751-753. Proceedings of International Society of Citriculture, IX Conference.

Jeppson, L.R., Keifer, H.H. and Baker, E.W. (1975). Mites Injurious to Economic Plants. University of California Press, Berkeley, USA.

Vacante, V. and Nucifora, A. (1986). A first list of the mites in citrus orchards in Italy, pp 177-188. In: Cavalloro, R., and Di Martino, E. (eds.). Integrated Pest Control in Citrus-Groves: Proceedings of the experts' meeting, Acireale, 26-29 March 1985. Rotterdam, Netherlands: Published for the Commission of the European Community by A.A. Balkema, Rotterdam/Boston.

2.1.4 Mediterranean fruit fly

Ceratitis capitata (Wiedemann) [Diptera: Tephritidae] – Mediterranean fruit fly; Medfly

Synonym(s): *Tephritis capitata* Wiedemann; *Ceratitis citriperda* Macleay; *Ceratitis hispanica* De Brême; *Pardalaspis asparagi* Bezzi.

Host(s): Medfly is a highly polyphagous species and its pattern of host relationships from region to region appears to relate largely to what fruits are available (White & Elson-Harris, 1994). In Hawaii (USA), 60 out of 196 fruit species examined over the years 1945-1985 were found as hosts of this pest at least once; the two most important hosts were *Coffea arabica* and *Solanum pseudocapsicum* (Liquido *et al.*, 1990). In the EPPO region, important hosts include apple, avocado, citrus, fig, kiwi fruit, mango, medlar, pear and *Prunus* spp. (CABI/EPPO, 1997).

Ceratitis capitata attacks a very wide range of deciduous and subtropical fruits, with over 200 hosts recorded (Smith *et al*., 1997). Hosts include: *Actinidia deliciosa* (kiwi fruit); *Anacardium occidentale* (cashew); *Ananas comosus* (pineapple); *Annona cherimola* (cherimoya); *Annona reticulata* (bullock's heart); *Antidesma dallachyana* (Herbert River-cherry, Queensland-cherry); *Arbutus unedo* (Irish strawberry); *Artocarpus altilis* (breadfruit); *Averrhoa carambola* (carambola); *Capsicum annuum* (bell pepper); *Capsicum frutescens* (chilli); *Carica papaya* (pawpaw); *Carissa edulis* (carandas plum); *Carissa macrocarpa* (Natal plum); *Casimiroa edulis* (white sapote); *Chrysophyllum cainito* (caimito); *Citrus aurantifolia* (lime); *Citrus aurantium* (sour orange); *Citrus limetta* (sweet lime); *Citrus limon* (lemon); *Citrus limonia* (mandarin lime); *Citrus madurensis* (calamondin); *Citrus maxima* (pummelo); *Citrus medica* (citron); *Citrus nobilis* (tangor); *Citrus* x *paradisi* (grapefruit); *Citrus reticulata* (mandarin); *Citrus reticulata* × *C. paradisi* (tangelo); *Citrus sinensis* (navel orange); *Coffea arabica* (arabica coffee); *Coffea liberica* (liberica coffee); *Cotoneaster* sp.; *Cucumis sativus* (cucumber); *Cydonia oblonga* (quince); *Cyphomandra betacea* (tamarillo); *Diospyros kaki* (persimmon); *Dovyalis caffra* (kei apple); *Eriobotrya japonica* (loquat); *Eugenia brasiliensis* (Brazil cherry, grumichama); *Eugenia uniflora* (Surinam cherry); *Feijoa sellowiana* (feijoa); *Ficus carica* (fig); *Ficus* spp. (fig); *Fortunella japonica* (round kumquat); *Fortunella* spp. (kumquat); *Garcinia livingstonei* (African mangosteen); *Garcinia mangostana* (mangosteen); *Harpephyllum caffrum* (Kaffir plum); *Juglans regia* (walnut); *Litchi chinensis* (lychee), *Lycopersicon esculentum* (tomato); *Macadamia tetraphylla* (rough-shell Queensland nut); *Malpighia glabra* (acerola); *Malus domestica* (apple); *Malus sylvestris* (crabapple); *Malus* spp. (apple); *Mangifera indica* (mango); *Manilkara zapota* (sapodilla); *Mespilus germanica* (medlar); *Mimusops elengi* (Spanish cherry); *Monstera deliciosa* (Mexican breadfruit); *Morus nigra* (black mulberry); *Muntingia calabura* (Jamaica cherry); *Musa* × *paradisiaca* (banana, plantain); *Myrciaria cauliflora* (jaboticaba); *Olea europaea* (olive); *Opuntia* sp. (prickly pear); *Opuntia ficus-indica* (Indian fig prickly pear); *Passiflora edulis* (purple passionfruit); *Pereskia aculeata* (Barbados gooseberry); *Persea americana* (avocado); *Phoenix dactylifera* (date-palm); *Physalis peruviana* (Cape gooseberry); *Pouteria sapota* (mammee sapote); *Pouteria viridis* (sapodella); *Prunus armeniaca* (apricot); *Prunus domestica* (plum); *Prunus ilicifolia* (chaparral tree); *Prunus persica* (peach); *Prunus persica* var. *nucipersica* (nectarine); *Prunus* spp. (stonefruit); *Psidium cattleianum* (cherry guava); *Psidium guajava* (guava); *Psidium littorale* (strawberry guava); *Punica granatum* (pomegranate); *Pyrus communis* (pear); *Rosa* spp. (rose); *Rubus loganobaccus* (loganberry); *Rubus ursinus* var. *loganbaccus* (boysenberry); *Rubus* spp. (raspberry); *Santalum album* (Indian sandalwood); *Santalum freycinetianum*; *Solanum incanum* (bitter apple); *Solanum melongena* (eggplant); *Solanum muricatum* (pepino); *Solanum nigrum* (black nightshade); *Solanum pseudocapsicum* (Jerusalem cherry); *Spondias cytherea* (Hog's plum); *Spondias purpurea* (purple mombin, Spanish plum); *Syzygium cumini* (black plum); *Syzygium jambos* (rose apple); *Syzygium malaccense* (malay-apple); *Syzygium samarangense* (water apple); *Terminalia catappa* (water almond); *Theobroma cacao* (cocoa); *Thevetia peruviana* (yellow oleander); and *Vitis vinifera* (grape) (CABI, 2004).

Distribution: Albania; Algeria; Angola; Argentina (localised); Australia (WA-restricted distribution); Benin; Bolivia; Botswana; Brazil; Burkina Faso; Burundi (localised); Cameroon; Cape Verde; Colombia; Comoros; Congo (localised); Costa Rica; Croatia (localised); Cyprus; Ecuador (localised); Egypt; El Salvador (localised); Ethiopia; France (localised); Gabon; Ghana; Greece; Guatemala (localised); Guinea (localised); Honduras (localised); Iran; Israel; Italy; Ivory Coast; Jordan; Kenya; Lebanon; Liberia; Libya (localised); Madagascar (localised); Malawi; Mali; Malta; Mauritius; Mexico; Morocco; Mozambique (localised); Namibia; Nicaragua; Niger; Nigeria (localised); Paraguay; Peru; Portugal; Reunion (localised); Saudi Arabia; Senegal; Sierra Leone; Slovenia; South Africa; Sudan; Switzerland (localised); Syria; Tanzania; Togo; Tunisia; Turkey; Uganda; Uruguay; USA (California, Hawaii); USSR; Venezuela; Yemen; Zambia; Zimbabwe (EPPO, 2004).

The distribution of Medfly in Australia is now limited to Western Australia and is mainly restricted to the horticultural and urban areas in the southwest of the State. The largest populations of the insect occur in the Perth metropolitan area and in towns in the southwest of the State (Woods, 1997). In all of the towns and areas south of Manjimup, Medfly can be found in summer only for short periods. It is not found in orchards during the cooler months. The Ord River Irrigation area in northern Western Australia is free of this pest.

All other States of Australia are free of Medfly. Occasional, isolated, small outbreaks sometimes occur in the city of Adelaide in South Australia and the Northern Territory due to the introduction of infested fruit by humans, but these outbreaks are quickly detected through extensive fruit fly surveillance networks, and the outbreaks are successfully contained and rapidly eradicated.

Biology: Adults are 4–5 mm in length with pale green eyes, mottled wings and a yellow body marked with white, brown, blue and black. Adults take 2–3 days to become sexually mature at 25°C (Krainacker *et al*., 1987). Medflies attack fruit that is beginning to colour (Smith *et al*., 1997). Peak adult emergence takes place in the early morning. Adult females must feed on protein (e.g. bacteria growing on fruit and plant surfaces) and on sugars (in honeydew or nectar) for several days before they can mature and lay their eggs (Smith *et al*., 1997). Mating takes place on host plants with ripening fruit. Adult can survive for up to a year in the laboratory but probably do not live more than two to three months in the field (Fletcher, 1989). Generally, adults live up to 2 months (CABI/EPPO, 1997; Christenson & Foote, 1960), although adult females can live for up to 6 months (Smith *et al*., 1997). This species has a relatively long reproductive phase (Fletcher, 1989).

Medfly development time is dependent upon environmental factors, with temperature being a key factor for all life stages. In general, the higher the temperature the faster the development time and *vice versa*. In cool regions, this species may overwinter as pupae or adults, while in warmer regions it is reproductively active throughout the year.

The developmental rate of Medfly reaches an upper limit at temperatures between 30 and 33°C and then decreases at temperatures above 35°C (Shoukry & Hafez, 1979). On average, under Australian conditions, development from egg to adult will take 28 to 34 days in the summer and 60 to 115 days in the winter (De Lima & Woods, 1996). Medfly activity is possible over winter when daily maximum temperatures exceed 12°C and they can survive the winter in both adult and immature stages (De Lima, 1998). In Australia, adults overwinter in citrus trees (Smith *et al*., 1997). Numbers fall in winter, and start increasing in spring. Populations are highest in late summer and early autumn (Smith *et al*., 1997).

Females lay 1–14 eggs per fruit, depending on its size (McDonald & McInnis, 1985), and can produce 300–1000 eggs throughout their lives (Fletcher, 1989). Eggs are white, 1 mm in length and deposited in batches of 2–30 beneath the skin in the albedo (rind) of ripening fruit (Smith *et al*., 1997). The eggs hatch within 2–4 days (up to 16–18 days in cool weather) (CABI/EPPO, 1997). Larvae are cream-coloured with a pointed head and squarish rear end. They hatch from the eggs and tunnel into the fruit pulp. Heavy mortality of eggs and young larvae, particularly in immature citrus fruit, is caused by oil released from oil cells in the rind ruptured during egg laying (Smith *et al*., 1997). In thicker-skinned varieties, larval death follows the formation of gum in and around the egg-laying site (Smith *et al*., 1997). The larvae feed for 6–11 days at 13–28°C (CABI/EPPO, 1997). Mature larvae are 6.5–9 mm in length, and leave the fruit to pupate in the top 50 mm of soil under the host plant (Smith *et al*., 1997). Adults emerge after 6–11 days at 24–26°C (longer in cool conditions) (CABI/EPPO, 1997).

In Australia, most damage to citrus occurs during late summer and early autumn, especially to early maturing varieties (Smith *et al*., 1997). This coincides with the end of the season for deciduous fruits. Mature deciduous fruits act as a reservoir for fruit flies because they migrate onto ripening citrus fruit at the end of the deciduous fruit season (Smith *et al*., 1997). Fruit damage results from puncturing of the rind during egg laying and from larvae feeding on the fruit pulp (Smith *et al*., 1997). In addition, organisms such as green mould (*Penicillium digitatum*) enter the fruit through the punctures and rots develop (Cayol *et al*., 1994; Smith *et al*., 1997). The life cycle takes 4–17 weeks, depending on the temperature (Smith *et al*., 1997). There are 4–5 generations per year, with the number of generations determined by temperature (Fletcher, 1989; Smith *et al*., 1997). In tropical and subtropical regions there may be as many as 12–13 generations a year.

Adult flight and the transport of infested fruits are the major means of movement and dispersal to uninfested areas. There is evidence that *C. capitata* can fly at least 20 km (Fletcher, 1989). Long distance flights of adults, particularly over water, have been recorded and when fruit is unavailable in an area, both immature and mature flies will rapidly disperse (Fletcher, 1989). However, when hosts are available and other conditions are favourable, the movements of the majority of adults seem to be restricted to a few hundred metres per week (Wong *et al*., 1982).

Coffea spp. are especially heavily attacked, although the attack on coffee does not impact on this crop as only the fleshy part of the fruit, which is discarded, is utilised by the larvae. However, in many areas coffee crops appear to act as an important reservoir from which other crops may be attacked. In some areas, wild hosts are important. For example, in northern Africa the boxthorn, *Lycium europaeum*, is an important overwintering host (Cayol, 1996).

Economic importance: Tephritid flies (Diptera: Tephritidae) are the most important dipteran pests of agriculture worldwide, and include 418 genera and 4352 species. Fruit flies are responsible worldwide for considerable restrictions on the international movement of fruit. This pest is an important pest in Africa and has spread to almost every other continent to become the single most important pest species in its family. It is highly polyphagous and causes damage to a very wide range of unrelated fruit crops. In Mediterranean countries, it is particularly damaging to citrus and peach. It may also transmit fruit-rotting fungi (Cayol *et al*., 1994).

Medfly is of quarantine significance throughout the world, especially for Japan and the USA. Its presence in Hawaii, but not in mainland USA, has contributed to its high international profile as a quarantine pest (Smith *et al*., 1997). It has reached all tropical and warm temperate landmasses with the exception of Asia. Its presence, even as temporary adventive populations, can lead to severe additional constraints for the export of fruits to uninfested areas in other continents. In this respect, *C. capitata* is one of the most significant quarantine pests for any tropical or warm temperate region in which it is not yet established (Smith *et al*., 1997).

References:

CABI (2004). Crop Protection Compendium – Global Module (Second edition). CAB International, Wallingford, UK.

CABI/EPPO (1997). *Ceratitis capitata*, pp 146–152. In: Smith, I.M., McNamara, D.G., Scott, P.R. and Holderness, M. (eds.). Quarantine Pests for Europe (Second edition). Data sheets on Quarantine Pests for the European Communities and for the European and Mediterranean Plant Protection Organization. CAB International/EPPO, Wallingford, UK.

Cayol, J.P. (1996). Box thorn, key early season host of the Mediterranean fruit fly. International Journal of Pest Management 42: 325-329.

Cayol, J.P., Causse, R., Louis, C. and Barthes, J. (1994). Medfly *Ceratitis capitata* Wiedemann (Diptera: Trypetidae) as a rot vector in laboratory conditions. Journal of Applied Entomology 117: 338-343.

Christenson, L.D. and Foote, R.H. (1960). Biology of fruit flies. Annual Review of Entomology 5: 171-192.

De Lima, F. (1998). Ecological studies of the Mediterranean fruit fly for area-wide control in South West Australia. Fifth International Symposium on Fruit Flies of Economic Importance. p 129.

De Lima, F. and Woods, B. (1996). Control of Mediterranean fruit fly in backyards. *Farmnote*, Department of Agriculture, Western Australia. Agdex 201/622.

EPPO (2004). PQR database (version 4.2). European and Mediterranean Plant Protection Organization, Paris, France.

Fletcher, B.S. (1989). Ecology; movements of tephritid fruit flies, pp 209-219. In: Robinson, A.S. and Hooper, G. (eds). Fruit Flies; Their Biology, Natural Enemies and Control. World Crop Pests, 3(B). Elsevier, Amsterdam, Netherlands.

Krainacker, D.A., Carey, J.R. and Vargas, R.I. (1987). Effect of larval host on life history traits of the Mediterranean fruit fly, *Ceratitis capitata*. Oecologia 73: 583–590.

Liquido, N.J., Cunningham, R.T. and Nakagawa, S. (1990). Host plants of Mediterranean fruit fly (Diptera: Tephritidae) on the Island of Hawaii (1949–1985 survey). Journal of Economic Entomology 83: 1863–1878.

McDonald, P.T. and McInnis, P.O. (1985). *Ceratitis capitata*: Effect of host fruit size on the numbers of eggs per clutch. Entomologia Experimentalis et Applicata 37: 207–213.

Shoukry, A. and Hafez, M. (1979). Studies on the biology of Mediterranean fruit fly *Ceratitis capitata*. Entomologia Experimentalis et Applicata 26: 33–39.

Smith, D., Beattie, G.A.C. and Broadley, R. (1997). Citrus pests and their natural enemies. Department of Primary Industry, Brisbane, Queensland.

White, I.M. and Elson-Harris, M.M. (1994). Fruit Flies of Economic Significance: Their Identification and Bionomics. Institute of Entomology and ACIAR, CAB International, Wallingford, UK. 601 pp.

Wong, T.T.Y., Whitehand, L.C., Kobayashi, R.M., Ohinata, K., Tanaka, N. and Harris, E.J. (1982). Mediterranean fruit fly: Dispersal of wild and irradiated and untreated laboratory-reared males. Environmental Entomology 11: 339–343.

Woods, B. (1997). Mediterranean fruit fly eradication in Western Australia – Overview, pp. 5–10. Proceedings from the National Mediterranean fruit fly Workshop, Perth.

2.1.5 Citrophilus mealybug

Pseudococcus calceolariae (Maskell) [Hemiptera: Pseudococcidae] – citrophilus mealybug

Synonym(s): *Dactylopius calceolariae* Maskell; *Erium calceolariae* (Maskell); *Pseudococcus citrophilus* Clausen; *Pseudococcus fragilis* Brain; *Pseudococcus gahani* Green.

Host(s): Citrophilus mealybug is a highly polyphagous species that has been recorded from hosts in 40 plant families (Ben-Dov, 1994). *Abutilon* (Indian mallow); *Arachis hypogaea* (groundnut); *Brachychiton*; *Brassica*; *Ceanothus*; *Chenopodium* (Goosefoot); *Citrus medica* (citron); *Conium maculatum* (Poison hemlock); *Crataegus* (hawthorn); *Cydonia oblonga* (quince); *Daucus carota* (carrot); *Dodonaea viscosa* (switch sorrel); *Eugenia*; *Ficus*; *Fragaria*; *Geranium* (cranesbill); *Hedera helix* (ivy); *Helianthus* (sunflower); *Heliotropium arborescens* (Cherry-pie); *Hibiscus* (rosemallows); *Juglans regia* (Carpathian walnut); *Laburnum anagyroides* (laburnum); *Ligustrum*, *Lolium* (ryegrass); *Malus domestica* (apple); *Malus sylvestris* (crab-apple); *Malva* (mallow); *Musa paradisiaca* (plantain); *Nerium oleander* (oleander); *Palmae* (plants of the palm family); *Pelargonium* (pelargoniums); *Pinus radiata* (radiata pine); *Pisum sativum* (pea); *Pittosporum tobira* (Japanese pittosporum); *Pittosporum undulatum* (Australian boxwood); *Polyscias*; *Prunus* (stone fruit); *Pyrus communis* (European pear); *Rheum hybridum* (rhubarb); *Rhododendron* (azalea); *Ribes sanguineum* (flowering currant); *Rosa* (roses); *Rubus* (blackberry, raspberry); *Schinus molle* (California peppertree); *Sechium edule*; *Solanum tuberosum* (potato); *Theobroma cacao* (cocoa); *Vitis vinifera* (grapevine).

Distribution: Australia (NSW, Qld, Tas, Vic); Chile; China; Czechoslovakia; France; Georgia (Republic); Ghana; Italy; Madagascar; Mexico; Morocco; Namibia; Netherlands; New Zealand; Portugal; South Africa; Spain; Ukraine; United Kingdom; and USA (California, Louisiana).

Biology: Females lay in excess of 700 eggs within a waxy ovisac. Neonate crawlers spend the first few days of their lives sheltering under the disintegrating ovisac before dispersing to feed. They usually do not move far from their feeding site for the first moult. At the end of the second instar, males spin a tubular, silken cocoon in which they develop through a short-lived third (about 2 days) and a longer-lived fourth non-feeding instar (about 4 days) before moulting into a tiny, winged adult with a pair of stout, waxy terminal filaments. Females develop through three immature instars and undergo a final moult to the adult form. Males, at the end of the second instar, and females before oviposition, often seek out sheltered spots under bark or old vegetation for further development. Neither stage feeds from then on, so physical protection is more important than a food source.

Mature females produce a sex pheromone that attracts crawling males from short distances (Rotundo & Tremblay, 1981) or flying males from distances in excess of 1 m (Rotundo *et al*., 1980). The pheromone attracts large numbers of males in the field, and has been used to detect three seasonal male flight peaks in Italy (Rotundo *et al*., 1979). Adult females may mate almost immediately, but then spend up to several weeks maturing their eggs. Mature females commonly move to a protected site to lay eggs over a period of up to 2 weeks. Parthenogenesis has not been reported in this species and experience suggests that sexual reproduction is obligate. In New Zealand there are probably up to three generations per year (Charles, 1981), in Australia four generations per year (Smith & Armitage, 1931) and in California three to four generations per year (Clausen, 1915).

Citrophilus mealybug feeds on the phloem of deciduous and evergreen plants in warm, temperate climates. Under these conditions, populations seldom reach sufficiently high levels to debilitate the plant, and the symptoms of attack are usually restricted to visual sighting of mealybugs or sooty mould. When mealybugs shelter in fruit, within the calyx, around the stalk, or under fruit sepals, they are often hidden from view and cannot be seen without cutting open the fruit. Sooty mould fungi growing around the calyx or sepals on excreted honeydew are a good indicator of the presence of mealybugs in the fruit.

Economic importance: Mealybugs cause direct damage to citrus by extracting large quantities of sap and producing honeydew that serves as the substrate for the development of sooty mould, which prevents photosynthesis in addition to making the plant unsightly. Citrophilus mealybug is an endemic pest throughout most of Australia, and is perhaps the most serious pest of citrus in South Australia (Altmann & Green, 1991). It is commonly found throughout the major fruit-growing regions in New Zealand and may be very common locally on most fruit crops (Charles, 1993). It can be a severe pest, at least locally, in Italy (Laudonia & Viggiani, 1986).

Mealybugs are pests for several reasons. They may debilitate parts of the plant through depletion of sap, transmission of disease and scarring of fruit (for example, citrophilus mealybug feeding under the 'button' of citrus fruit causes a necrotic halo mark). A heavy infestation can cause fruit drop (Altmann & Green, 1991). More commonly, the presence of mealybugs in other perennial fruit crops leads to unacceptable growth of sooty mould fungi on honeydew deposits on the fruit, either as a deposit on the cheek or around the stalk, calyx or sepals. For growers producing fresh fruit for export markets, the presence of mealybugs or sooty mould may be sufficient to limit the sale of that fruit to local markets at reduced prices. Some countries accept the fruit following fumigation, but this is costly and results in poorer quality fruit with a shorter shelf life.

References:

Altmann, J. and Green, A. (1991). The biological control of citrophilus mealybug in citrus. In: Sustainable Management of Pests, Diseases and Weeds. Australian Society of Horticultural Science, Macquarie University, Sydney. pp 363-368.

Ben-Dov, Y. (1994). A systematic catalogue of the mealybugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance. Intercept Limited, Andover, UK. 686 pp.

Charles, J.G. (1981). Distribution and life history of the longtailed mealy bug, *Pseudococcus longispinus* (Homoptera: Pseudococcidae), in Auckland vineyards. New Zealand Journal of Zoology 8: 285-293.

Charles, J.G. (1993). A survey of mealybugs and their natural enemies in horticultural crops in North Island, New Zealand, with implications for biological control. Biocontrol Science and Technology 3: 405-418.

Clausen, C.P. (1915). Mealybugs of citrus trees. California Agricultural Experimental Station Bulletin No. 258.

Laudonia, S. and Viggiani, G. (1986). Natural enemies of the citrophilus mealybug (*Pseudococcus calceolariae* Mask.) in Campania. Bolletino del Laboratorio di Entomologia Agraria 'Fillippo Silvestri' di Portici. 43 suppl: 167-171.

Rotundo, G., Tremblay, E. and Giacometti, R. (1979). Final results of mass captures of the citrophilus mealybug males (*Pseudococcus calceolariae* Mask.) (Homoptera Coccoidea) in a citrus grove. Bollettino del Laboratorio di Entomologia Agraria 'Filippo Silvestri' di Portici 36: 266-274.

Rotundo, G., Tremblay, E. and Papa, P. (1980). Short-range orientation of *Pseudococcus calceolariae* (Mask.) males (Homoptera Coccoidea) in a wind tunnel. Bollettino del Laboratorio di Entomologia Agraria 'Filippo Silvestri', Portici. 37:31-37.

Rotundo, G. and Tremblay, E. (1981). Scent trailing by virgin females of *Pseudococcus calceolariae*. Journal of Chemical Ecology 7: 85-88.

Smith, H.S. and Armitage, H.M. (1931). The biological control of mealybugs attacking citrus. California Agricultural Experimental Station Bulletin No. 509.

2.1.6 Scales

Chrysomphalus dictyospermi (Morgan) [Hemiptera: Diaspididae] – palm scale

Lepidosaphes gloverii (Packard) [Hemiptera: Diaspididae] – Glover's scale

Parlatoria pergandii Comstock [Hemiptera: Diaspididae] – chaff scale

Parlatoria ziziphi (Lucas) [Hemiptera: Diaspididae] – black parlatoria scale

Unaspis yanonensis (Kuwana) [Hemiptera: Diaspididae] – arrowhead scale

Synonym(s):

Chrysomphalus dictyospermi (Morgan): *Aspidiotus dictyospermi* (Morgan) Cockerell; *Aspidiotus mangiferae* Cockerell; *Chrysomphalus dictyospermatis* Lindinger; *Chrysomphalus castigatus* Mamet.

Lepidosaphes gloverii (Packard): *Aspidiotus gloverii* Packard; *Insulaspis gloverii* (Packard); *Mytilaspis gloverii* (Packard); *Myrtilaspis gloveri* (Packard); *Myrtilococcus gloveri* (Packard); *Myrtilococcus gloverii* (Packard).

Parlatoria pergandii Comstock: *Parlatoria sinensis* Maskell; *Parlatoria proteus* v. *pergandii* (Cockerell) Cockerell; *Parlatoria pergandii* (Cockerell) Hunter; *Parlatoria pergandii* (Cockerell) Lindinger; *Syngenaspis pergandei* (Cockerell) MacGillivray.

Parlatoria ziziphi (Lucas): *Coccus zizyphus* Lucas; *Parlatoria zizyphus* (Lucas).

Unaspis yanonensis (Kuwana): *Chionaspis yanonensis* Kuwana; *Prontaspis yanonensis* (Kuwana)

Host(s):

Chrysomphalus dictyospermi: *Areca catechu* (betelnut palm); *Citrus aurantiifolia* (lime); *Citrus aurantium* (sour orange); *Citrus maxima* (pummelo); *Citrus* x *paradisi* (grapefruit); *Citrus sinensis* (navel orange); *Citrus unshiu* (satsuma); *Cocos nucifera* (coconut); *Howea forsteriana* (paradise palm); *Mangifera indica* (mango); *Musa paradisiaca* (plantain); *Olea europaea* subsp. *europaea* (olive); *Palmae*; *Persea americana* (avocado); *Plumeria* (frangipani); *Rosa* (roses); *Solanum melongena* (aubergine); *Syzygium malaccense* (malay-apple); *Taxus baccata* (English yew); *Zingiber* (ginger).

Lepidosaphes gloverii: *Alocasia macrorrhiza* (giant taro); *Carissa*; *Citrus*; *Codiaeum variegatum* (croton); *Erythrina* spp.; *Euonymus* (spindle trees); *Fortunella* (kumquat); *Mangifera indica* (mango); *Poncirus*.

Parlatoria pergandii: *Asparagus setaceus* (asparagus fern); *Citrus aurantiifolia* (lime); *Citrus limon* (lemon); *Citrus maxima* (pummelo); *Citrus reticulata* (mandarin); *Citrus sinensis* (navel orange); *Citrus x paradisi* (grapefruit); *Citrus*; *Malus pumila* (apple); *Prunus* (stone fruit); *Prunus domestica* (damson).

Parlatoria ziziphi: *Parlatoria ziziphi* has been recorded on several species of Citrus and other Rutaceae such as *Severinia buxifolia* and *Murraya paniculata*. *Campnosperma brevipetiolata*; *Citrus* spp.; *Citrus aurantium* (bergamot orange, bitter orange, marmalade orange, seville orange, sour orange); *Citrus reticulata* (clementine, mandarin, mandarin orange, satsuma orange, tangerine, tangor); *Cocos nucifera* (coconut, coconut palm); *Mangifera indica* (mango); *Nipa* spp.; *Nipa fruticans*.

Unaspis yanonensis: Only attacks *Citrus* spp. In Japan, it is found on all types of citrus except for specific Japanese hybrids known as Natsudaidi and *Citrus junos* (Ohkubo, 1980). *Citrus* spp., *Citrus limon* (lemon), *Citrus x paradisi* (grapefruit), *Citrus reticulata* (mandarin), *Citrus sinensis* (navel orange), *Citrus unshiu* (satsuma).

Distribution:

Chrysomphalus dictyospermi: Algeria; Angola; Argentina; Australia; Azerbaijan; Bahamas; Benin; Bermuda; Brazil; Bulgaria; Cameroon; Caroline Islands; Canary Islands; Cape Verde; Chile; China; Colombia; Congo, Cook Islands; Costa Rica; Ivory Coast, Cuba; Dominican Republic; Easter Island; Ecuador; Egypt; Ethiopia; Federated States of Micronesia; Fiji; France; French Polynesia; Georgia (Republic); Greece; Guadeloupe; Guatemala; Guinea; Guyana; Honduras; India; Indonesia; Iraq; Iran; Israel; Italy; Jamaica; Johnston Island; Kenya; Kiribati; Laos; Lebanon; Libya; Madagascar; Malaysia; Mali; Malta; Marshall Islands; Mauritius; Mexico; Morocco; Myanmar; New Caledonia; Nicaragua; Niger; Nigeria; Norfolk Island; Northern Mariana Islands; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Portugal; Puerto Rico; Réunion; Samoa; Sao Paulo; Senegal; Sierra Leone; Solomon Islands; Somalia; Spain; South Africa; Sri Lanka; Sudan; Sumatra; Suriname; Syria; Tanzania; Thailand; Togo; Tonga; Trinidad and Tobago; Tunisia; Turkey; Turkmenistan; Tuvalu; Uganda; Ukraine; United Kingdom; Uruguay; USA; USSR; Venezuela; Vietnam; Yugoslavia; Zambia; Zimbabwe (CABI, 2004).

Lepidosaphes gloverii: Algeria; Argentina; Australia; Belarus; Bolivia; Cameroon; China (Hong Kong, Taiwan); Cook Islands; Costa Rica; Cuba; Dominican Republic; Ecuador;

Egypt; Federated States of Micronesia; Fiji; France; French Polynesia; Gambia; Greece; Guinea; Honduras; India; Indonesia; Israel; Italy; Jamaica; Japan; Korea, DPR; Korea, Republic of; Lebanon; Madagascar; Malaysia; Mauritius; Mexico; Morocco; Mozambique; Myanmar; Nigeria; Northern Mariana Islands; Pakistan; Papua New Guinea; Philippines; Puerto Rico; Réunion; Russian Federation; Samoa; Senegal; Sierra Leone; South Africa; Spain; Sri Lanka; Suriname; Thailand; Tonga; Trinidad and Tobago; Turkey; Uganda; USA (Alabama, California, Florida, Hawaii, Louisiana, Texas); Venezuela (CABI, 2004).

Parlatoria pergandii: Algeria; Argentina; Australia; Brazil; Cameroon; China; Cook Islands; Cuba; Dominican Republic; Egypt; El Salvador; Eritrea; Federated States of Micronesia; France; Greece; Guatemala; Honduras; India; Indonesia; Iran; Israel; Italy; Jamaica; Japan; Libya; Malta; Mexico; Morocco; Nicaragua; Nigeria; Norfolk Island; Pakistan; Peru; Philippines; Puerto Rico; Samoa; Senegal; Seychelles; Sierra Leone; Singapore; Somalia; South Africa; Spain; Syria; Tanzania; Thailand; Togo; Trinidad and Tobago; Tunisia; Turkey; USA (Alabama, California, Florida, Louisiana, Mississippi, South Carolina, Texas).

Parlatoria ziziphi: Algeria; Argentina; Bangladesh; Barbados; Brazil; Cambodia; Cameroon; Central African Republic; China; Colombia; Congo; Cuba; Cyprus; Dominica; Dominican Republic; Egypt; Eritrea; Ethiopia; France; Gambia; Georgia; Ghana; Greece; Guam; Guatemala; Guinea; Guyana; Haiti; India; Indonesia; Iran; Israel; Italy; Ivory Coast; Jamaica; Japan; Korea; Laos; Lebanon; Liberia; Libya; Malaysia; Mali; Malta; Mauritius; Micronesia; Morocco; Myanmar; New Zealand; Nigeria; Pakistan; Panama; Peru; Philippines; Portugal; Puerto Rico; Russian Federation; Saudi Arabia; Senegal; Sierra Leone; Singapore; South Africa; Spain; Sri Lanka; Syria; Thailand; Togo; Trinidad and Tobago; Tunisia; Turkey; USA (Florida [Fasulo & Brooks, 1997], Hawaii, Mississippi); Venezuela; Vietnam (CABI, 2004).

Unaspis yanonensis: China; Fiji; France; Italy; Japan; and Korea (CABI, 2004).

Biology: Most armoured scales are very small (2-4 mm long) and their body is covered with hard, waxy 'armour'. The cover may be separate or attached to the body (Smith *et al*., 1997). The armour covers adult females and immature males. Adult scale females are immobile, being wingless and often without legs. Adult males are tiny, fragile, usually with one pair of wings, well-developed legs and lack mouthparts (they do not feed). Adult females are elongate-oval (Williams & Watson, 1988). Nymphs are active only during the first instar (or crawler) stage and may travel some distance to a new plant where they become sessile for the remaining nymphal (larval) instars. The crawlers settle down and feed upon plant juices by inserting their piercing-sucking mouthparts into the host plant. First instars (crawlers) are able to disperse by active movement and by wind.

In cooler regions during winter, development of all scales progresses very slowly up to the adult stage for females and up to the pupal stage for males. At this stage, development stops until the onset of warmer weather. Once the warmer weather starts, adult males emerge and mating begins with adult females. Females then start reproducing within one to two months. Crawlers hatch and move onto young, new season fruit after petal fall and continue moving for several weeks. From this time until summer, the population tends to be at the same stage of development. Scale insects develop well during summer, even at low humidity.

Armoured scales do not produce honeydew, but their feeding can damage fruit or cause leaf drop. They inject toxins into plant tissues and at high populations can cause tree death.

These species are polyphagous and are often found in large numbers on leaves. Scales feed on foliage, fruit, twigs and the bark of the trunk (Timmer & Duncan, 1999). Leaves are the preferred feeding sites but fruit and branches are also attacked (Fasulo & Brooks, 2001). Most scales settle on upper leaf surfaces and the lower surfaces only become infested at very high population densities (Fasulo & Brooks, 2001).

Many scale species have shown an ability to adapt to new hosts and new environments (McClure, 1983). Adult female scales are sedentary. They attach to vegetative plant surfaces as nymphs, insert their mouthparts into vascular plant tissue and begin secreting protective armour. Eggs are laid beneath the female and remain there until they hatch. Crawlers move from the female and search the plant surface for a suitable point of attachment. Although crawlers may wander for a time, they usually settle and become attached to a vegetative surface within hours of leaving the female. Crawlers may be distributed by wind, or by a range of mechanical or biological vectors including propagation material, plantation equipment and personnel. Short-range transfer of scales is generally attributed to the movement of crawlers, either through their own efforts or by vectors. Long-range movement of scales occurs when gravid females are transferred *in situ* with the vegetative material upon which they are feeding. Short-range dispersal would occur readily by wind (Willard, 1974).

The depletion of plant sap reduces host vigour and foliage and fruit may be discolored with yellow streaking and spotting. Heavy infestations cause chlorosis of foliage and stems, premature dropping of leaves, moderate to severe defoliation, dieback of twigs and branches, stunting and distortion of fruit, spots on fruit and premature fruit drop. Severe infestations can drastically affect plant vigour and may even kill the plant (Fasulo & Brooks, 2001). For a short period after hatching, the first instars are attracted to light and move upwards towards the apical twigs or onto the fruit, especially if leaf fall has occurred.

Chrysomphalus dictyospermi is polyphagous. Eggs hatch 1 to 24 hours after being layed. The mobile nymphs settle in less than 24 hours and undergo their first moult 8 days later. The second and final nymphal instar stages last about 13 days. Three generations usually occur each year. A fourth may occur in the advent of warm autumn climatic conditions. Mobile nymphs initially settle on the upper surfaces of old leaves and later on new shoots and young fruits. Heavily infested leaves dry up and fall, branches wilt and infested fruit is deformed. Individuals have difficulty surviving in winter (HYPPZ, 2003).

Lepidosaphes gloverii is a minor pest of citrus. Although the species is polyphagous in tropical countries it is unable to survive hot, dry summers (Gill, 1997).

The spread of *Parlatoria* spp. depends on relative humidity and temperature (Gerson, 1980). They do not spread well under low relative humidity and high temperatures. Australia has a wide range of climate and many areas are suitable for the establishment and spread of these scale insects. *Parlatoria pergandii* populations establish on limbs and trunks, but can be widely distributed on a tree. Adults and nymphs feed on leaves, stems and fruit, which can sometimes lead to fruit drop. Chaff scales are often associated with gumming, flaking and splitting of bark, causing dieback of branches and sometimes killing the tree. This species has been found to cover nearly 100% of bark and 70% of twigs of *Citrus sinensis* in the Cook Islands (Walker & Dietz, 1979).

Parlatoria ziziphi females lay from 8 to 20 eggs (Fasulo & Brooks, 1997). Females feeding on fruit lay more eggs than those feeding on branches or foliage. Eggs hatch in 5–

12 days and larvae pass through nymphal stages over 23–35 days (Sweilem *et al*., 1984). Depending upon the region of the world, there are from three to seven generations per year and each generation may take 30–93 days to develop. In colder weather, the time required is much longer (Fasulo & Brooks, 1997). All stages of development can be found throughout the year. Population density appears to be significantly and positively influenced by temperature and negatively influenced by relative humidity and rainfall, although the latter was not found to be significant by El Bolok *et al*. (1984a). Highest population densities are usually observed in the lowest part of a tree (El Bolok *et al*., 1984b). Leaves are the preferred feeding sites but fruit and branches are also attacked (Fasulo & Brooks, 1997). Generally, scales firmly attach to the fruit so that they cannot easily be removed, causing rejection in most fresh fruit markets. Most scales settle on the upper leaf surfaces and the lower surfaces only become infested at very high population densities (Fasulo & Brooks, 1997).

Unaspis yanonensis attacks fruits, leaves and small branches but not large branches or trunks. Only the second and third generations are found on fruit (Ohkubo, 1980). Attacks on branches and leaves lead to leaf fall, and possibly to complete dieback. Leaves and branches begin to die back at a density of 1.1 females per leaf (Ohkubo, 1980), while a density of 8 females per leaf in spring is likely to lead to complete dieback of the tree within the year (Ohgushi & Nishino, 1968). This species has three generations per year (Nohara, 1962). The fertilised adult female overwinters. Each generation has two population peaks and the duration of these is affected by day length and temperature. In Japan, the third generation is only seen in southern regions (Ohkubo, 1980). This pest survives best in shade and at high temperatures the natural mortality is high on the upper parts of trees. In France, attacks are mainly observed on the north side of trees, the south side remaining practically free from the pest (Bénassy & Pinet, 1972). This scale has a low dispersal potential. In common with other diaspids, the main dispersal stage of this scale is the first instar, which may be naturally dispersed by wind and animals. Internationally, it is carried on citrus plants for planting or on citrus fruits.

Economic importance: Scale insects are major citrus pests and being small are difficult to detect by inspection, especially at low population levels. They generally live around the sepals or under the calyx of the fruit from flowering onwards. Damage is usually caused by removal of plant sap and results in senescence of the branch or leaf drop.

Attacked fruits lose their commercial value because of the feeding punctures of the pest (Ohkubo, 1980). *Parlatoria* scales have been reported causing serious damage in East Java on varieties of *Citrus nobilis* where shoots and leaves were attacked (Kalshoven & Van der Laan, 1981).

References:

Bénassy, C. and Pinet, C. (1972). Notes bio-écologiques sur *Unaspis yanonensis* dans les Alpes-Maritimes. Annales de Zoologie Ecologie Animale 4: 187-212.

CABI (2004). Crop Protection Compendium. CAB International, Wallington, UK.

El Bolok, M.M., Sweilem, S.M. and Abdel Aleem, R.Y. (1984a). Seasonal variations in the population of *Parlatoria ziziphus* (Lucas) at Giza region. Bulletin de la Societe Entomologique d'Egypte 65:281-288.

El Bolok, M.M., Sweilem, S.M. and Abdel Aleem, R.Y. (1984b). Effect of different trees, different cardinal directions, tree core and leaf surface on the distribution of

Parlatoria ziziphus (Lucas) in correlation with the year seasons. Bulletin de la Societe Entomologique d'Egypte 65: 289-299.

Fasulo, T.R. and Brooks R.F. (1997). Scale pests of Florida citrus. University of Florida, Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Fact Sheet ENY-814.

Fasulo, T.R. and Brooks, R.F. (2001). Scale pests of Florida citrus. Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Fact Sheet ENY-814.

Gerson, U. (1980). The scale insect *Parlatoria paranoid* Comstock and its natural enemies in Israel. Seminar on biological control of scale insects and aleurodids on citrus. Boletin del Servicio de Lucha Biologica Contra Plagas e Inspeccion Fitopatoloica 21: 21-53.

Gill, R.J. (1997). The Scale Insects of California. Part 3: The Armoured Scales (Homoptera: Coccoidea: Diaspididae). Technical Series in Agricultural Biosystematics and Plant Pathology No. 3. Department of Food and Agriculture, Sacramento, California, USA. 307 pp.

HYPPZ (2003). Palm scale: *Chrysomphalus dictyospermi* Morgan [Insecta: Homoptera: Diaspididae]. http://www.inra.fr/Internet/Produits/HYPPZ/RAVAGEUR/6chrdic.htm

Kalshoven, L.G.E. and Van der Laan, P.A. (1981). Pests of crops in Indonesia. Pests of crops in Indonesia (revised). Ichtiar Baru, Jakarta, Indonesia. 701 pp.

McClure, M.S. (1983). Reproduction and adaptation of exotic hemlock scales (Homoptera: Diaspididae) on their new and native hosts. Environmental Entomology 12: 1811-1815.

Nohara, K. (1962). Studies on the biology of *Unaspis yanonensis*. Science Bulletin of the Faculty of Agriculture, Kyushu University No. 20.

Ohgushi, R. and Nishino, T. (1968). Preliminary report on the forecasting of the arrowhead scale appearance on the basis of the seasonal thermal index. Proceedings of the Association for Plant Protection of Kyushu 14: 42-43.

Ohkubo, N. (1980). Ecology and control of the arrowhead scale, *Unaspis yanonensis* Kuwana. Review of Plant Protection Research 13: 1-11.

Smith, D., Beattie, G.A.C. and Broadley, R. (1997). Citrus pests and their natural enemies: Integrated Pest Management in Australia. Department of Primary Industries, Brisbane, Queensland and Horticultural Research and Development Corporation, Australia. 272 pp.

Sweilem, S.M., El Bolok, M.M. and Abdel Aleem, R.Y. (1984). Biological studies on *Parlatoria ziziphus* (Lucas) (Homoptera: Diaspididae). Bulletin de la Societe Entomologique d'Egypte 65: 301-317.

Timmer, L.W. and Duncan, L.W. (1999). Citrus health management. The American Phytopathological Society, St. Paul, Minnesota, USA. pp. 197.

Walker, A.K. and Dietz, L.L. (1979). A review of entomophagous insects in the Cook Islands. New Zealand Entomology 7: 70-82.

Willard, J.R. (1974). Horizontal and vertical dispersal of California red scale, *Aonidiella aurantii* (Mask.), (Homoptera: Diaspididae) in the field. Australian Journal of Zoology 22: 531-548.

Williams, D.J. and Watson, G.W. (1988). The Scale Insects of the Tropical South Pacific Region. Part 1. The Armoured Scales (Diaspididae). CAB International, Wallingford, UK. 289 pp.

2.1.7 Whiteflies

Aleurothrixus floccosus (Maskell) [Hemiptera: Aleyrodidae] – woolly whitefly

Parabemisia myricae (Kuwana) [Hemiptera: Aleyrodidae] – bayberry whitefly

Synonym(s):

Aleurothrixus floccosus (Maskell): *Aleurodes floccosa* Maskell; *Aleurothrixus howardi* (Quaintance); *Aleyrodes horridus* Hempel; *Aleyrodes howardi* (Quaintance); *Aleurothrixus horridus* (Hempel).

Parabemisia myricae (Kuwana): *Bemisia myricae* Kuwana.

Hosts:

Aleurothrixus floccosus (Maskell): *Anacardium occidentale* (cashew); *Annona reticulata* (custard apple); *Baccharis genistelloides*; *Bougainvillea* sp.; *Cicca acida* (karmay); *Citrofortunella microcarpa* (calamondin); *Citrus aurantiifolia* (key lime, lime, sour lime); *Citrus aurantium* (bergamot orange, sour orange); *Citrus decumana*; *Citrus limon* (lemon); *Citrus maxima* (pummelo, shaddock); *Citrus reticulata* (mandarin, mandarin orange); *Citrus sinensis* (navel orange, orange, sweet orange, Valencia orange); *Citrus* x *nobilis* (king mandarin, king orange); *Citrus x paradisi* (grapefruit); *Coccoloba uvifera* (Jamaican kino, sea grape); *Coffea arabica* (Arabian coffee, arabica coffee); *Dieffenbachia* sp. (dumb cane); *Diospyros kaki* (Chinese persimmon, persimmon); *Eugenia uniflora* (Brazil cherry, Florida cherry); *Ficus* spp. (fig); *Gloriosa superba* (flame lily, glory lily); *Guaiacum officinale* (lignum vitae); *Licania tomentosa*; *Lucuma caimito*; *Malpighia glabra* (Barbados cherry); *Mangifera indica* (mango); *Manilkara zapota* (sapodilla); *Parquetina nigrescens*; *Phoradendron* sp.; *Plumeria* sp. (frangipani); *Pouteria campechiana* (eggfruit); *Psidium guajava* (guava); *Sida rhobifolia* (Queensland hemp); *Solanum melongena* (aubergine, eggplant); *Spondias lutea*, *Spondias purpurea* (red mombin); *Triplaris surinamensis* (CABI, 2004).

Parabemisia myricae (Kuwana): *Acer* sp. (maple); *Camellia sinensis* (tea); *Carya illinoensis* (pecan); *Chiococca alba* (snowberry); *Citrus limon* (lemon); *Citrus* spp.; *Cydonia oblonga* (quince); *Diospyros kaki* (persimmon); *Elaeocarpus serratus* (Ceylon olive); *Ficus carica* (fig); *Ficus* sp. (fig); *Lamium* sp. (deadnettle); *Laurus nobilis* (bay, laurel, sweet bay); *Lycopersicon esculentum* (tomato); *Maclura pomifera* (Osage orange); *Maesa japonica*; *Malva neglecta* (mallow); *Malus communis*; *Mercurialis annua* (annual mercury); *Morella rubra* (Chinese arbutus); *Morus alba* (white mulberry); *Morus* sp. (mulberry); *Myrtus communis* (true myrtle); *Parthenocissus quinquefolia* (Virginia creeper); *Persea americana* (avocado); *Polygonum* sp. (knotgrass); *Prunus avium* (cherry); *Prunus domestica* (plum); *Prunus mume* (Japanese apricot); *Prunus persica* (peach); *Prunus salicina* (Japanese plum); *Prunus triflora*; *Psidium guajava* (guava); *Punica granatum* (pomegranate); *Pyrus communis* (pear); *Quercus acutissima* (sawthorn oak); *Quercus serrata* (oak); *Rhododendron* sp. (azalea, rhododendron); *Rosa* sp. (rose); *Rubus* sp. (blackberry, raspberry); *Salix babylonica* (weeping willow); *Salix gracilistyla* (rosegold pussy willow); *Salix* spp. (willow); *Solanum nigrum* (common nightshade); *Sonchus* sp. (sow thistle); *Vitis* spp. (grape) (Hamon *et al*., 1990; Luo & Zhou, 1997; Mound & Halsey, 1978; Uygun *et al*., 1990).

Distribution:

Aleurothrixus floccosus (Maskell): Algeria; Angola; Argentina; Bahamas; Barbados; Belize; Benin; Brazil; Chile; Colombia; Congo; Costa Rica; Cuba; Cyprus; Dominica; Ecuador; Egypt; El Salvador; France (localised); French Polynesia; Gambia; Guadeloupe; Guyana; Haiti; India; Israel; Italy; Jamaica; Japan; Kenya; Lebanon; Malawi; Malta; Mauritius; Mexico; Morocco; Niger; Nigeria; Panama; Paraguay; Peru; Philippines; Portugal; Puerto Rico; Reunion; Singapore; Spain; Suriname; Tanzania; Togo; Trinidad and Tobago; Tunisia; United Kingdom; USA (California, Florida, Hawaii, Texas); Venezuela; Zambia (EPPO, 2004).

Parabemisia myricae (Kuwana): Algeria; China; Cyprus (localised); Egypt; Greece; Israel; Italy (localised); Ivory Coast; Japan; Lebanon; Papua New Guinea; Portugal (localised); Spain (localised); Tunisia; Turkey (localised); Ukraine (localised); USA (California, Florida, Hawaii); Venezuela; Vietnam (EPPO, 2004) and Croatia (Zanic *et al*., 2000).

Biology: Females of *Aleurothrixus floccosus* prefer completely expanded leaves for oviposition. Females lay between 53–178 eggs either singly, in small groups, a circle, a partial circle, or in concentric rings. Eggs are usually deposited on the underside of mature leaves and inserted into leaf tissues. The species has also been reported as living on the underside of young leaves and ovipositing both there and on fruit (Reuther *et al*., 1989). The female inserts her mouthparts into the leaf underside and then rotates while depositing eggs (Onillon & Abbassi, 1973). The first larval stage is light green while subsequent stages are brown with a wide fringe of shiny, white, waxy plates. Adults are yellow, sluggish and seldom fly (Reuther *et al*., 1989). This pest has 4-6 generations per year, with hibernation of the various nymphal stages during the winter. The number of generations per year is very dependent on ambient climatic parameters. At constant temperatures of 17°C, 22°C, 27°C and 30°C it was shown that development from egg stage to adult stage took 80 days, 45 days, 30 days and 28 days, respectively. At higher temperatures, death rates of eggs and nymphs are very high and at lower temperatures development is slower.

There are 4 nymphal instar stages. As the nymph grows, it secretes a white, waxy and powdery substance that covers the body. Nymphs are active only during the first instar (or crawler) stage and become sessile for the remaining nymphal (larval) instars. Pupae are usually covered by white wax threads, which are very conspicuous on heavily infested leaves. Adults and larvae damage the host plant by sucking sap and excreting honeydew onto the fruit and leaves, leading to sooty mould growth that interferes with photosynthesis. This pest is spreading on many plant species. It is mainly transported via infested plant material. Thus, it is recommended that phytosanitary measures should be enforced to limit further spread of the insect.

Reproduction of *Parabemisia myricae* is primarily by parthenogenesis and males occur only exceptionally (Uygun *et al*., 1990). Adults fly morning and evening, redistributing themselves within a crop and locating leaves suitable for feeding and oviposition (Meyerdirk & Moreno, 1984). In citrus groves in Turkey, Uygun *et al*. (1990) noted that at low population densities, oviposition occurs on very young, actively growing citrus foliage that has not yet completely unfolded. Fully expanded (mature) leaves may be chosen later, but old leaves are never chosen. At high population densities, oviposition may also take place on young fruits and shoots (Uygun *et al*., 1990). Females live for up to 6 days and produce an average of 70 eggs. Eggs are 0.17-0.23 mm in length, are white when newly laid, but turn blackish during the course of development (Walker & Aitken, 1985). Eggs are deposited either singly, in circles or half circles along leaf margins and on the veins. Nymphs are active only during the first instar (or crawler) stage and become sessile for the remaining nymphal (larval) instars. Length ranges from 0.25-0.65 mm over the 3 larval instar stages. A waxy secretion surrounds larvae. This species hibernates in the larval stage or in the puparium. During warm weather, some adults may emerge and even oviposit in winter. However, complete development from egg to adult never occurs during winter. The life cycle takes about 24 days at 60 ± 5% R.H. There are 7-8 generations per year. Whitefly occurrence is enhanced by high humidity. The developmental threshold temperature is 10.2°C and the optimum development temperature is 25-26°C.

High population densities cause direct damage to plants by sucking nutrients from young leaves and excreting honeydew onto the fruit and leaves, leading to sooty mould growth that interferes with photosynthesis (Uygun *et al*., 1990; Walker & Aitken, 1985). Direct and indirect feeding damage caused by *P. myricae* can result in defoliation of trees (Rose *et al*., 1981). Other types of feeding damage include discolouration and deformations in very young leaves. Heavy infestations can result in premature leaf drop, especially during periods of dry weather.

On citrus in California, adult females lay eggs selectively on new, small foliage, often referred to as feather growth (Jeppson, 1989). Eggs, each attached with a supporting pedicel, are laid on both sides of the leaves. On hatching, the nymphs (larvae) feed on the lower surface of the leaves. The larval stages have a clear, wax fringe around the body margin. Complete larval development can occur on green wood (Uygun *et al*., 1990). The life cycle requires 21 days for completion under variable day/night conditions of 21°C to 17.3°C and 65-100% R.H. (Rose *et al*., 1981). Adults primarily feed on leaves, but they also feed and lay eggs on fruit and green angular wood (Rose *et al*., 1981).

Under field conditions in California, *P. myricae* has a strong preference to oviposit on the actively growing foliar terminals of lemon trees instead of the middle and mature terminals (Walker & Aitken, 1985). Within young terminals, newly laid eggs are concentrated on the apical 5-6 cm where leaves are youngest. When first instars (crawlers) of *P. myricae* were experimentally placed on young, middle and mature leaves, it was found that 49, 35 and 0% successfully developed to the adult stage respectively. Five generations per year have been reported in California (Walker & Aitken, 1985).

In Israel, larvae and adults are found on citrus and avocado trees throughout the winter (Swirski *et al*., 1986). The oviposition rate of *P. myricae* in winter was low, but rose steeply in the spring. The density of larvae on the lower side of leaves was higher than on the upper side. Substantial numbers (45.4%) of larvae survived the winter on avocado trees. Emergence of adults increased at the end of February, reaching a peak in early March, and ceasing at the end of March or beginning of April.

In Turkey, the population development of *P. myricae* was studied on lemon, grapefruit, orange and mandarin in an 8-year-old orchard from January 1986 to July 1987 by Atay & Sekeroglu (1987). Population densities of immatures remained low in 1986 until July and then increased to a peak in mid-September. Immature populations were also low early in 1987 but reached a peak in June-July. The population trends were similar on all food plants, but the number of aleyrodids per leaf was highest on lemon, followed in descending order by grapefruit, orange and mandarin. Larval mortality was high, with only 8-16% of the eggs laid reaching the pupal stage. Adults caught in yellow sticky traps in 1986 showed similar population trends to the larvae, remaining low in numbers early in the season and reaching a peak by September. In 1987, almost no adults were trapped until June, and a slight population increase was observed in July.

In laboratory studies conducted by Uygun *et al*. (1990), the developmental time from egg to adult was 79.7, 41.7, 24.4 and 22 days at 15, 20, 25 and 30°C, respectively. At a fluctuating temperature of 25-35°C, the developmental time was 24.2 days. With increasing relative humidity at 25°C constant temperature, the total developmental time decreased significantly from 26.7 days at 40% R.H. to 20.3 days at 90% R.H. The mortality rate was lowest at 25°C and highest at 30°C. In Cyprus, up to nine generations occur per year (Orphanides, 1991).

In Turkey, Ulusoy *et al*. (1999) studied the effect of 6 citrus and 5 non-citrus host plants on the developmental period of immature stages of *P. myricae*. The developmental time on the citrus host plants from egg stage to adult was found to be 16.1, 16.1, 19.2, 20.0, 24.4 and 29.3 days on lemon, mandarin, grapefruit, sweet orange, sour orange and *Poncirus trifoliata*, respectively. The developmental time on the non-citrus host plants was 15.7, 20.4, 20.8, 23.8 and 26.4 days on grapevine, peach, rose, mulberry and pomegranate respectively. The mortality rate during the egg stage was lowest on lemon and rose and was highest on sweet orange and peach. The total mortality rate of all immature stages was lowest on sour orange and grapevine but highest on *Poncirus trifoliata* and peach.

Vector relationship: In Turkey, *P. myricae* has been shown to be able to transmit citrus chlorotic dwarf (CCD) (Korkmaz *et al*., 1996). It was not possible to transmit the causal agent mechanically to citrus seedlings or herbaceous plants by leaf-inoculation or by knife cuts, simulating pruning. According to the results, vector transmission appeared to be the primary means of transmission of CCD.

Economic importance: In citrus, damage is caused by whiteflies both directly through sap removal and indirectly through a reduction of photosynthesis resulting from the development of sooty mould growing on honeydew deposits (Reuther *et al*., 1989). *Parabemisia myricae* is considered to be one of the six most injurious whitefly pests (Onillon, 1990). Rose & Rosen (1991) describe it as very damaging to citrus in California. Until biological control was established it was one of the most serious pests of citrus both in Turkey (Sengonca *et al*., 1993) and Israel (Swirski *et al*., 1985). In Florida, *P. myricae* has been recorded as damaging citrus seedlings when the natural balance was disturbed by the use of chemicals that eliminated a parasitoid but not the pest (Hamon *et al*., 1990). In Algeria, it is regarded as a citrus pest (Berkani & Dridi, 1992).

References:

Atay, S. and Sekeroglu, E. (1987). On the population fluctuations of bayberry whitefly, *Parabemisia myricae* Kuwana (Homoptera: Aleyrodidae) on different citrus hosts, pp 59-67. Turkiye I. Entomoloji Kongresi Bildirileri, 13-16 Ekim -1987, Ege Universitesi, Bornova, Izmir.

Berkani, A. and Dridi, B. (1992). Presence in Algeria of *Parabemisia myricae* Kuwana (Homoptera: Aleyrodidae), a pest species of Citrus. Fruits 47: 539-540.

CABI (2004). Crop Protection Compendium. CAB International, Wallingford, UK.

EPPO (2004). PQR database (version 4.2). European and Mediterranean Plant Protection Organization, Paris, France.

Hamon, A.B., Nguyen, R. and Browning, H. (1990). The bayberry whitefly, *Parabemisia myricae*, in Florida (Homoptera: Aleyrodidae: Aleyrodinae). Florida Department of

Agriculture and Consumer Services, Division of Plant Industry, Entomology Circular No. 328.

Jeppson, L.R. (1989). Biology of citrus insects, mites and molluscs, pp 1-87. In: Reuther, W., Calavan, E.C. and Carmen, G.E. (eds.). The Citrus Industry. Volume V. Crop protection, postharvest technology, and early history of citrus research in California. Division of Natural Resources, University of California, California, USA.

Korkmaz, S., Kersting, U., Ertugrul, B. and Cinar, A. (1996). Transmission and epidemiology of citrus chlorotic dwarf (CCD) disease in the eastern Mediterranean region of Turkey. Journal of Turkish Phytopathology 25: 71-76.

Luo, Z.Y. and Zhou, C.M. (1997). Record of whitefly (Aleyrodidae) on tea plants. Journal of Tea Science 17: 201-206.

Meyerdirk, D.E. and Moreno, D.S. (1984). Flight behaviour and colour-trap preference of *Parabemisia myricae* (Kuwana) (Homoptera: Aleyrodidae) in a citrus orchard. Environmental Entomology 13: 167-170.

Michalopoulos, G. (1989). First records of the bayberry whitefly, *Parabemisia myricae* (Kuwana) in Greece. Entomologia Hellenica 7: 43-45.

Mifsud, D. (1997). Biological control in the Maltese Islands - past initiatives and future programmes. Bulletin OEPP 27: 77-84.

Mound, L.A. and Halsey, S.H. (1978). Whitefly of the world: A systematic catalogue of the Aleyrodidae (Homoptera) with host plant and natural enemy data. British Museum (Natural History) Publication No. 787. 340 pp.

Onillon, J.C. (1990). The use of natural enemies for the biological control of whiteflies, pp. 287-313. In: Gerling, D. (ed.). Whiteflies: their Bionomics, Pest Status and Management. Intercept Limited, Andover, Hants, UK.

Onillon, J.C. and Abbassi, M. (1973). Notes bio-ecologiques sur l'aleurode floconneux des agrumes *Aleurothrixus floccosus* Mask. (Homoptera: Aleurodidae) et moyens de lutte. Al Awamia 49: 99-117.

Orphanides, G.M. (1991). Biology and biological control of *Parabemisia myricae* (Kuwana) (Homoptera: Aleyrodidae) in Cyprus. Cyprus Agricultural Research Institute Technical Bulletin No. 135. 6 pp.

Reuther, W., Calavan, E.C. and Carman, E.G. (1989). The citrus industry, Vol.5, Division of Agriculture and Natural Resources, University of California. Publication Number 3326. pp 374.

Rose, M. and Rosen, D. (1991). *Eretmocerus debachi* n. sp. (Hymenoptera: Aphelinidae), an effective parasite of *Parabemisia myricae* (Homoptera: Aleyrodidae). Israel Journal of Entomology 25-26: 199-207.

Rose, M., DeBach, P. and Woolley, J. (1981). Potential new citrus pest: Japanese bayberry whitefly. California Agriculture 35: 22-24.

Sengonca, C., Uygun, N., Kersting, U. and Ulusoy, M.R. (1993). Successful colonization of *Eretmocerus debachi* (Hymenoptera: Aphelinidae) in the Eastern Mediterranean Citrus region of Turkey. Entomophaga 38: 383-390.

Swirski, E., Blumberg, D., Wysoki, M. and Izhar, Y. (1985). Data on the phenology and biological control of the Japanese bayberry whitefly, *Parabemisia myricae*, in Israel. Phytoparasitica 13: 73.

Swirski, E., Izhar, Y., Wysoki, M. and Blumberg, D. (1986). Overwintering of the Japanese bayberry whitefly, *Parabemisia myricae*, in Israel. Phytoparasitica 14: 281-286.

Ulusoy, M.R., Vatansever, G. and Uygun, N. (1999). The influence of different host plants on the development of *Parabemisia myricae* (Kuwana) (Homoptera: Aleyrodidae). Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz 106: 517-522.

Uygun, N., Ohnesorge, B. and Ulusoy, R. (1990). Two species of whiteflies on citrus in Eastern Mediterranean: *Parabemisia myricae* (Kuwana) and *Dialeurodes citri* (Ashmead). Morphology, biology, host plant and control in Turkey. Journal of Applied Entomology 110: 471-482.

Walker, G.P. and Aitken, D.C.G. (1985). Oviposition and survival of bayberry whitefly, *Parabemisia myricae* (Homoptera: Aleyrodidae) on lemons as a function of leaf age. Environmental Entomology 14: 254-257.

Zanic, K., Kacic, S. and Katalinic, M. (2000). Whitefly pest species (Homoptera: Aleyrodidae) on citrus trees. Agriculturae Conspectus Scientificus Poljoprivredna Znanstvena Smotra 65: 51-59.

2.1.8 Citrus pyralid

Cryptoblabes gnidiella (Millière) [Lepidoptera: Pyralidae] – Citrus pyralid

Synonym(s): *Albinia casazzar* Briosi; *Albinia gnidiella* Millière; *Cryptoblabes aliena* Swezey; *Ephestia gnidiella* (Millière).

Hosts: *Cryptoblabes gnidiella* is polyphagous and able to use almost any plant, but it is most often encountered on commercial crops.

Allium sativum (garlic) (Swailem & Ismail, 1972); *Annona muricata* (soursop) (CABI, 2004); *Azolla anabaena* (azolla) (Sasmal & Kelshreshtha, 1978); *Azolla pinnata* (ferny azolla) (Takara, 1981); *Citrus* spp. (Ascher *et al*., 1983; Carter, 1984; Swailem & Ismail, 1972); *Citrus limon* (lemon) (Sternlicht, 1979); *Citrus sinensis* (sweet orange) (Silva & Mexia, 1999); *Coffea* spp. (coffee) (CABI, 2004); *Eleusine corana* (ragi) (Singh & Singh, 1997); *Eriobotrya japonica* (loquat) (Ascher *et al*., 1983); *Ficus carica* (fig) (Carter, 1984); *Gossypium hirsutum* (cotton) (Swailem & Ismail, 1972); *Macadamia ternifolia* (macadamia nut) (Wysoki, 1986); *Malus domestica* (apple) (Carter, 1984); *Mangifera indica* (mango) (Hashem *et al*., 1997); *Mespilus germanica* (medlar) (Carter, 1984); *Morus alba* (mulberry) (CABI, 2004); *Musa* sp. (banana) (Jager & Daneel, 1999); *Myrica faya* (firetree) (Duffy & Gardner, 1994); *Oryza sativa* (rice) (Sasmal & Kulshreshtha, 1978); *Panicum miliacem* (millet panic) (Singh & Singh, 1997); *Paspalum dilatatum* (paspalum) (Yehuda *et al*., 1991/1992); *Pennisetum glaucum* (pearl millet); *Pennisetum typhoideus* (pearl millet) (Kishore, 1991); *Persea americana* (avocado) (Ascher *et al*., 1983); *Phaseolus* sp. (bean) (CABI, 2004); *Prunus domestica* (plum, prune) (Carter, 1984); *Prunus persica* (peach) (Carter, 1984); *Punica granatum* (pomegranate) (Carter, 1984); *Ricinus communis* (castor bean) (Singh & Singh, 1997); *Saccharum officinarum* (sugarcane) (CABI, 2004); *Schinus terebinthifolius* (Brazilian pepper tree) (CABI, 2004); *Solanum melongena* (eggplant) (Swailem & Ismail, 1972); *Sorghum vulgare* (sorghum) (Singh & Singh, 1995); *Swietinia macrophylla* (mahogany) (Akanbi, 1973); *Tarchardia lacca* (Yunus & Ho, 1980); *Vaccinium* sp. (blueberry) (Molina, 1998); *Vitis vinifera* (grapevine) (Ascher *et al*., 1983; Carter, 1984; Hashem *et al*., 1997); *Zea mays* (maize) (Swailem & Ismail, 1972).

Distribution: *Cryptoblabes gnidiella* is a cosmopolitan species in warm climates but is unable to survive winters in cooler temperate areas into which it may be imported with produce. Records from the Netherlands, Scandinavian countries (Denmark, Finland, Norway and Sweden) and the United Kingdom are interceptions on imported material (Karsholt, 1996). This species is native to the Mediterranean region but has been introduced to Malaysia, New Zealand, Hawaii and parts of tropical and subtropical America (Carter, 1984).

Austria (Karsholt, 1996); Bermuda (CABI, 2004); Egypt (Swailem & Ismail, 1972); France (Karsholt, 1996); Greece (Karsholt, 1996); India (Singh & Singh, 1995); Israel (Yehuda *et al*., 1991/1992); Italy (Karsholt, 1996); Lebanon (CABI, 2004); Liberia (CABI, 2004); Malaysia (Yunus & Ho, 1980); Malta (Karsholt, 1996); Portugal (Karsholt, 1996); New Zealand (Zhang, 1994); Nigeria (Akanbi, 1973); Pakistan (CABI, 2004); Sierra Leone (CABI, 2004); South Africa (Kruger, 1998); Spain (Karsholt, 1996); Thailand (Takara, 1981); Turkey (Karsholt, 1996); Uruguay (CABI, 2004); United States (Hawaii) (Zimmerman, 1958).

Biology: Adult females lay about 100 eggs on the fruit or foliage of host plants. Females have been observed to lay eggs singly or in groups of three on both surfaces of maize leaf (Swailem & Ismail, 1972). Eggs hatch in 4–7 days (Carter, 1984). There are 5 larval instars. Fully-grown larvae are 11.9 mm long and the duration of the larval period is around 13 days (Carter, 1984). Larvae mainly attack fruit, but also feed on foliage, bark and twigs (Liotta & Mineo, 1964). Larvae often occur in association with infestations by other pests (e.g. with the mealybug *Planococcus citri* on citrus and following attack by the European vine moth, *Lobesia botrana,* on grapes (Carter, 1984)). Pupation takes place on the food plant or on the ground. The moth is attracted to honeydew created by mealybugs (Zimmerman, 1958). There are three or four generations a year in southern Europe and up to five in North Africa (Carter, 1984).

In Israel, this pest overwinters in avocado orchards on fresh or dry fruits remaining on the trees, on leaves infested with *Protopulvinaria pyriformis*, on the weed *Paspalum dilatatum* and on various other plants (Yehuda *et al*., 1991/1992). Yehuda *et al*. (1991/1992) observed five generations in the field, with overwintering moths emerging during March and April to produce a first generation that did not cause any damage to crops. The fifth generation, flying in October to November, established the overwintering population (Yehuda *et al*., 1991/1992).

Silva & Mexia (1999) studied *C. gnidiella* population dynamics in sweet orange groves (*Citrus sinensis*), the importance of damage caused by *C. gnidiella*, and the interspecific association between *C. gnidiella* and the citrus mealybug (*Planococcus citri*) in four groves in the Alagarve, Portugal. Total *C. gnidiella* males captured in each grove showed a similar pattern and the greater percentage of males were trapped during the June–September period (except for the grove Fazenda Grande). It was possible to identify three or four distinct peaks. The results suggested a significant positive association (P = 0.05) between *C. gnidiella* and *P. citri*, supporting the hypothesis of several other authors that a *P. citri* infestation is necessary for attack by *C. gnidiella* in citrus. Even low levels of *C. gnidiella* larval infestation caused serious damage by fruit drop and, consequently, a high loss of sweet orange production, mainly in navel cultivars.

In India, 9 generations have been reported on hybrid sorghum by Singh & Singh (1995). The pest was active from the end of March to November and overwintered in the pupal stage with the onset of cold weather.

Economic importance: Citrus pyralid is a polyphagous pest of numerous crops and is recorded as a secondary pest in citrus groves, often associated with the attacks of other species (Silva & Mexia, 1999).

In Egypt, it is considered a serious polyphagous pest in fruit orchards, as well as in vegetables and field crops (Hashem *et al*., 1997). It is a pest of avocado, citrus, grape, loquat and pomegranate in the Mediterranean area (Balachowsky, 1972). It is noted to be an important pest of avocado in Israel, of *Azolla*, rice and sorghum in India (Singh & Singh, 1995), and sporadically of maize or other crops in any warm part of the world.

References:

Akanbi, M.O. (1973). The major insect borers of mahogany – a review towards their control – what step next? Research Paper Forest Series No. 16, Federal Department of Forest Research, Nigeria. 8 pp.

Ascher, K.R.S., Eliyahu, M., Gurevitz, E. and Renneh, S. (1983). Rearing the honeydew moth, *Cryptoblabes gnidiella*, and the effect of diflubenzuron on its eggs. Phytoparasitica 11: 195–198.

Balachowsky, A.S. (1972). Entomologie appliquée a l'agriculture. Tome II. Lépidoptères, pp. 1059–1634. Deuxieme volume. Zygaenoidea Pyraloidea Noctuoidea. Masson et Cie, Paris, France.

CABI (2004). Crop Protection Compendium. CAB International, Wallingford, UK.

Carter, D.J. (1984). Pest Lepidoptera of Europe with special reference to the British Isles. Series Entomologica (Dordrecht) 31: 1–431.

Duffy, B.K. and Gardner, D.E. (1994). Locally established botrytis fruit rot of *Myrica faya*, a noxious weed in Hawaii. Plant Disease 78: 919–923.

Hashem, A.G., Tadros, A.W. and Abo-Sheasha, M.A. (1997). Monitoring the honeydew moth, *Cryptoblabes gnidiella* Millière in citrus, mango and grapevine orchards (Lepidoptera: Pyralidae). Annals of Agricultural Science Cairo 42: 335–343.

Jager, K. de and Daneel, M.S. (1999). Protect banana bunches against pests with bags. Neltropika Bulletin 305: 32–33.

Karsholt, O. (1996). The Lepidoptera of Europe: A Distributional Checklist. Apollo Books, Stenstrup, Denmark. 380 pp.

Kishore, P. (1991). Sources of resistance amongst world pearl millet, *Pennisetum typhoides* (Burm.), germplasms to important insect pests. Journal of Entomological Research 15: 212–217.

Kruger, M. (1998). Identification of the adults of Lepidoptera inhabiting *Ravenelia macowaniana* Pazschke (Uredinales) galls on *Acacia karoo* (Fabaceae) in Southern Africa. African Entomology 6: 55–74.

Liotta, G. and Mineo, G. (1964). La *Cryptoblabes gnidiella* Millière o tignola rigata degli agrumi (Lep., Pyralidae) osservazioni biologiche in Sicilia. Bollettino 1st Entomologia Agraria e dell'Osservatorio di Fitopatologia di Palermo 5: 155–172.

Molina, J.M. (1998). Lepidoptera associated with blueberry cultivation in Western Andalusia. Boletin de Sanidad Vegetal Plagas 24: 763–772.

Sasmal, N. and Kulshreshtha, J.P. (1978). Biology and control of the pests *Cryptoblabes gnidiella* and *Nymphula responsalis* of *Azolla anabaena*, a nitrogen fixing fern. Oryza 15: 204–207.

Silva, E.B. and Mexia, A. (1999). The pest complex *Cryptoblabes gnidiella* (Millière) (Lepidoptera: Pyralidae) and *Planococcus citri* (Risso) (Homoptera: Pseudococcidae) on sweet orange groves (*Citrus sinensis* (L.) Osbeck) in Portugal: Interspecific association. Boletin de Sanidad Vegetal Plagas 25: 89–98.

Singh, Y.P. and Singh, D.K. (1995). Bionomics of *Cryptoblabes gnidiella* Millèr. a pest of sorghum. Advances in Agricultural Research in India 3: 119–129.

Singh, Y.P. and Singh, D.K. (1997). Host plants, extent of damage and seasonal abundance of earhead caterpillar *Cryptoblabes gnidiella* Millèr. Advances in Agricultural Research in India 7: 133–137.

Sternlicht, M. (1979). Improving control of the citrus flower moth, *Prays citri*, by mass trapping of males. Alon Hanotea 34: 189–192.

Swailem, S.M. and Ismail, I.I. (1972). On the biology of the honey dew moth *Cryptoblabes gnidiella*, Millière. Bulletin de la Societe Entomologique d'Egypte 56: 127–134.

Takara, J. (1981). Insect pests on *Azolla pinnata* at Bangkhen, Thailand. International Rice Research Newsletter 6: 12–13.

Wysoki, M. (1986). New records of Lepidopterous pests of macadamia in Israel. Phytoparasitica 14: 147.

Yehuda, S.B., Wysoki, M. and Rosen, D. (1991/1992). Phenology of the honeydew moth, Cr*yptoblabes gnidiella* (Millière) (Lepidoptera: Pyralidae), on avocado in Israel. Israel Journal of Entomology 25–26: 149–160.

Yunus, A. and Ho, T.H. (1980). List of Economic Pests, Host Plants, Parasites and Predators in West Malaysia (1920–1978). Ministry of Agriculture, Kuala Lumpur, Malaysia. 538 pp.

Zhang, B.C. (1994). Index of Economically Important Lepidoptera. CAB International, Wallingford, UK.

Zimmerman, E.C. (1958.) Insects of Hawaii, Volume 8. University of Hawaii Press, Honolulu, Hawaii.

2.1.9 Citrus flower moth

Prays citri Millière [Lepidoptera: Yponomeutidae] – citrus flower moth

Synonym(s): *Acrolepia citri* (Millière); *Prays nephelomima* Meyrick.

Host(s): *Citrus* is the only known primary host. *Citrus aurantifolia* (lime); *Citrus limon* (lemon); *Citrus* x *paradisi* (grapefruit); *Citrus reticulata* (mandarin, tangerine); *Citrus sinensis* (sweet orange) (Ibrahim & Shahateh, 1984). Secondary hosts include *Casimiroa edulis* (white sapote) and *Ligustrum lucidum* (glossy privet) (Sinacori & Mineo, 1997).

Part(s) of plant affected: Flower, fruit, leaf (Ibrahim & Shahateh, 1984).

Distribution: *Prays citri* is widespread in the Mediterranean region, where it was probably introduced with some citrus varieties (Balachowsky, 1966; Gomez, 1990; Carvalho & Aguiar, 1997). It is also present in some African countries. According to Common (1990), *P. citri* has not been reported in Australia although seven *Prays* species are endemic in Australia. This moth had previously been reported in Australia by EPPO but was removed for EPPO (2002) because in an authoritative checklist on the genus, *Prays citri* was not included for Australia (Nielsen & Edwards, 1996). Identifications of *Prays citri* on citrus from the east of Turkey, the Middle East, Asia and the Pacific (such as Sri Lanka, Malaysia, Philippines, Pakistan, Fiji and Samoa previously reported by EPPO) are likely to be erroneous as no voucher material has ever been seen and all *P. citri* specimens examined had been misidentified.

Algeria; Cyprus; Egypt (CIE, 1982); Fiji (CABI, 2004); France (CIE, 1982); Greece (Katsoyannos, 1996); India (Carter, 1984); Israel; Italy (CIE, 1982); Japan (Carter, 1984); Lebanon; Libya (CIE, 1982); Malaysia (Yunus & Ho, 1980); Malta; Mauritius; Morocco (CIE, 1982); New Zealand; Pakistan; Philippines (CABI, 2004); Portugal (CIE, 1982); Samoa (CABI, 2004); South Africa; Spain (CIE, 1982); Sri Lanka (CABI, 2004); Syria; Tunisia; Turkey; Zimbabwe (CIE, 1982).

Biology: *Prays citri* attacks the leaves, flowers and developing fruits (Ibrahim & Shahateh, 1984). Lime (*Citrus aurantifolia*) is the most susceptible to the pest, followed by lemon, sweet orange, mandarin and grapefruit (Ibrahim & Shahateh, 1984). Generally, eggs are laid individually on flowers and sometimes on young fruit. Upon hatching, the larvae bore into flowers and small fruits. Cocoons may be found on fruits, flowers and leaves. Temperature influences the lifespan of the moth. At 25°C, the complete life cycle takes 20 days. Experiments show that the female lifespan is greater than 37.2 days at 10°C, while at 26°C it is less than 5 days. Adults have twilight and nocturnal habits. Females begin laying eggs 2-5 hours after mating. Each female lays from 60-156 eggs (Garrido & Ventura, 1993, Carvalho & Aguiar, 1997; Mendonca *et al.*, 1997).

In the Mediterranean region, all stages of the insect may be found throughout the year. The number of generations a year varies from 3-16, depending on climatic conditions. For example, in Sicily (Italy) there are 11 generations, and in Israel between 8 and 10 generations. Population levels are low in winter and spring and high in summer and autumn. The threshold for development is approximately 10°C, and the first attacks occur in the spring when the temperatures exceed 10°C. Attacks are significant when the trees are in bloom (Jeppson, 1989).

Field observations in Sicily on citrus (especially lemon), indicate that the females lay eggs not only on the flower buds and the developing fruit but also on leaf shoots and larger fruits. The larvae develop successfully, however, only from eggs laid on buds or shoots (Mineo, 1967). The larvae feed not only on reproductive organs, binding them together with silk threads, but also on young fruits. Pupation occurs among damaged flowers or leaves. Separate matings are necessary between each batch of viable eggs laid (Liotta & Mineo, 1963).

In 1978–79 in Sicily, using pheromone traps with capsules containing 160 mµ g of (Z)-7-tetradecenal, Mineo *et al*. (1980) found that males of *P. citri* were caught throughout almost the entire year, being rare only at the end of February and the beginning of March. The highest catches were observed between mid-May and mid-July and between early October and early November. Weekly catches per trap varied greatly according to the location of the trap, from 33 to 1110. Fruit infestation rate was 10–40% in the autumn of 1978, but in 1979 it was 4–16%. Flower infestation was low until April but reached 100% in May and remained very high until the end of June, when the average number of eggs and larvae per flower varied from 6.2 to 7.8. Flower infestation began again in the second half of August and reached 100% in September, with the numbers of eggs and larvae averaging 10 per flower. The relationship of male catches to the degree of infestation is largely influenced by cultural and climatic factors.

Studies conducted in lemon orchards in Sicily found eggs and larvae of this species year round, although they were more abundant in the first 3 weeks of January, from the beginning of May to mid-July, and from the end of August until the end of December (Mineo *et al*., 1980). The results indicate that control of *P. citri* should be affected only when necessary during periods of late flowering, i.e. in May–June or August–September (Mineo, 1993).

Economic importance: Citrus flower moth is a serious pest of citrus in the Mediterranean area. Attacks on *Citrus limon* (lemon) are of particular economic importance. Up to 90% loss in flower production in Spain and 15-70% flower reduction in Portugal have been attributed to *P. citri* (Garrido *et al*., 1984; Mendonca *et al*., 1997). It is also considered an economically important pest in Egypt on lime tree (Ibrahim & Shalateh, 1984).

References:

Balachowsky, A.S. (1966). Entomologie appliquée à l'agriculture, pp. 563-578. Tome II, Vol. I. Masson et Cie, Paris, France.

CABI (2004). Crop Protection Compendium. CAB International, Wallingford, UK.

Carter, D.J. (1984). Pest Lepidoptera of Europe with special reference to the British Isles. Series Entomologica (Dordrecht) 31: 1–431.

Carvalho, J.P. de and Aguiar, A.M.F. (1997). Pragas dos citrinos na ilha da Madeira. Direccao Regional de Agricultura da Regiao Autonoma da Madeira, Madeira, Spain. 411 pp.

CIE (1982). *Prays citri* (Mill.). Distribution Maps of Pests, Series A (Agricultural), Map No. 443. Commonwealth Agricultural Bureaux, London, UK. 2 pp.

Common, I.F.B. (1990). Moths of Australia. Melbourne University Press, Carlton, Victoria, Australia. 535 pp.

EPPO (2002). PQR database (version 4.1). European and Mediterranean Plant Protection Organization, Paris, France.

Garrido, A. and Ventura, J.J. (1993). Plagas de los cítricos. Bases para el manejo integrado. M.A.P.A., Madrid, Spain.

Garrido, A., Busto, T. and Tarancón, J. (1984). Assessment of adults of *Prays citri* Mill (Lepidoptera: Hyponomeutidae) with a synthetic pheromone and the relation to damage. Anales del Instituto Nacional de Investigaciones Agrárias, Agrícola 25: 147–154.

Gomez, A.C. de (1990). Biología y morfología de las orugas. Tomo VIII. M.A.P.A., Madrid, Spain.

Ibrahim, S.S. and Shahateh, W.A. (1984). Biological studies on the citrus flower moth *Prays citri* Miller in Egypt. Arab Journal of Plant Protection 2: 4–9.

Jeppson, L.R. (1989). Biology of citrus insects, mites and molluscs, pp. 1–87. In: Reuther, W., Calavan, E.C. and Carmen, G.E. (eds.). The Citrus Industry, Volume V. Crop protection, postharvest technology, and early history of citrus research in California. University of California Division of Natural Resources, California, USA.

Katsoyannos, P. (1996). Integrated insect pest management for citrus in Northern Mediterranean countries. Benaki Phytopathologique Institute, Athens, Greece. 110 pp.

Liotta, G. and Mineo, G. (1963). Osservazioni sulla biologia del *Prays citri* Millière in Sicilia. *Bollettino* 1st di Entomologia Agraria e dell'Osservatorio di Fitopatologia di Palermo 5: 75–104.

Mendonca, T.R., Martins, F.M. and Lavadinho, M.P. (1997). Flight pattern of the citrus moth *Prays citri* (Millière) (Lepidoptera, Yponomeutidae) in a lemon orchard in Mafra and development of attack intensity. Boletin de Sanidad Vegetal Plagas 23: 479–483.

Mineo, G. (1967). Notes on the behaviour of *Prays citri* Millière (Lepidoptera: Hyponomeutidae). Bollettino dell'Istituto di Entomologia Agraria e dell'Osservatorio di Fitopatologia di Palermo 7: 277–282.

Mineo, G. (1993). Effects of cultural techniques on the control of citrus flower moth (*Prays citri* Millière) infestations (Lepidoptera: Yponomeutidae). Frustula Entomologica 16: 89-95.

Mineo, G., Mirabello, E., Busto, T. and Viggiani, G. (1980). Catches of adults of *Prays citri* Millière (Lepidoptera: Plutellidae) with pheromone traps and progress of infestations in lemon groves in eastern Sicily. Bollettino del Laboratorio di Entomologia Agraria 'Filippo Silvestri', Portici 37: 177-197.

Nielsen, E.S. and Edwards, E.D. (1996). Checklist of the Lepidoptera of Australia. CSIRO, Canberra, Australia.

Sinacori, A. and Mineo, N. (1997). Two new host plants of *Prays citri* and *Contarinia citri*. Informatore Fitopatologico 47: 13–15.

Yunus, A. and Ho, T.H. (1980). List of Economic Pests, Host Plants, Parasites and Predators in West Malaysia (1920–1978). Ministry of Agriculture, Kuala Lumpur, Malaysia. 538 pp.

2.1.10 Western flower thrips

Frankliniella occidentalis (Pergande) [Thysanoptera: Thripidae] – Western flower thrips

Synonym(s): *Euthrips helianthi* Moulton; *Euthrips occidentalis* Pergande; *Frankliniella californica* Moulton; *Frankliniella canadensis* Morgan; *Frankliniella chrysanthemi* Kurosawa; *Frankliniella conspicua* Moulton; *Frankliniella dahliae* Moulton; *Frankliniella dianthi* Moulton; *Frankliniella nubila* Treherne; *Frankliniella umbrosa* Moulton; *Frankliniella venusta* Moulton; *Frankliniella helianthi* (Moulton); *Frankliniella moultoni* Hood; *Frankliniella trehernei* Morgan.

Host(s): *Allium cepa* (onion); *Amaranthus palmeri* (Palmer amaranth); *Arachis hypogaea* (groundnut); *Begonia*; *Beta vulgaris* (beetroot); *Beta vulgaris* var. *saccharifera* (sugarbeet); *Brassica oleracea* var. *capitata* (cabbage); *Capsicum annuum* (bell pepper); *Carthamus tinctorius* (safflower); *Chrysanthemum* x *morifolium* (chrysanthemum); *Citrus* x *paradisi* (grapefruit); *Cucumis melo* (melon); *Cucumis sativus* (cucumber); *Cucurbita maxima* (banana squash); *Cucurbita pepo* (ornamental gourd); *Cucurbitaceae* (cucurbits); *Cyclamen*; *Dahlia*; *Daucus carota* (carrot); *Dianthus caryophyllus* (carnation); *Euphorbia pulcherrima* (poinsettia); *Ficus carica* (common fig); *Fragaria ananassa* (strawberry); *Fuchsia*; *Geranium* (cranesbill); *Gerbera jamesonii* (African daisy); *Gladiolus* hybrids (sword lily); *Gossypium* (cotton), *Gypsophila* (baby's breath); *Hibiscus* (rosemallow); *Impatiens* (balsam); Kalanchoe; *Lactuca sativa* (lettuce); *Lathyrus odoratus* (sweet pea), *Leucaena leucocephala* (leucaena); *Limonium sinuatum* (sea pink); *Lycopersicon esculentum* (tomato); *Malus domestica* (apple); *Medicago sativa* (lucerne); *Petroselinum crispum* (parsley); *Phaseolus vulgaris* (common bean); *Pisum sativum* (pea); *Prunus armeniaca* (apricot), *Prunus domestica* (plum); *Prunus persica* (peach); *Prunus persica* var. *nucipersica* (nectarine); *Purshia tridentata* (bitterbrush); *Raphanus raphanistrum* (charlock); *Saintpaulia ionantha* (African violet); *Secale cereale* (rye); *Sinapis arvensis* (wild mustard); *Sinningia speciosa* (gloxinia); *Solanum melongena* (aubergine); *Syzygium jambos* (rose apple); *Triticum aestivum* (wheat); *Vitis vinifera* (grapevine).

Distribution: Albania; Argentina; Australia (NSW, Qld, SA, Tas, Vic, WA); Austria; Belgium; Brazil; Bulgaria; Canada; Central Russia; Chile; Colombia; Costa Rica; Croatia; Cyprus; Czech Republic; Denmark; Dominican Republic; Eastern Siberia; Ecuador; Estonia; Finland; France; Germany; Greece; Guatemala; Guyana; Hungary; Ireland; Israel; Italy; Japan; Kenya; Korea; Kuwait; Lithuania; Macedonia; Malaysia; Martinique; Mexico; Netherlands; New Zealand; Norway; Peru; Poland; Portugal; Puerto Rico; Réunion; Romania; Russian Far East; Russian Federation; Scotland; Slovakia; Slovenia; South Africa; Southern Russia; Spain; Sri Lanka; Sweden; Switzerland; Turkey; United Kingdom; USA; Venezuela; Western Siberia; Zimbabwe (EPPO, 2004; CABI/EPPO, 1998).

Biology: Under favourable conditions, *F. occidentalis* will reproduce almost continuously, with up to 15 generations in a year being recorded under glass (Bryan & Smith, 1956; Lublinkhof & Foster, 1977). Adult thrips sometimes enter closed buds, and eggs are laid concealed within such buds in the parenchymatous tissues; they are also laid in similar tissues of leaves, flower parts and young fruits. Eggs hatch in about 4 days at 27°C, but take 13 days at 15°C. The eggs are probably susceptible to desiccation and subject to high mortality, but there is also high mortality due to failure of first instar larvae to emerge safely from their egg.

There are two active larval stages and two non-feeding pupal stages. First-instar larvae begin feeding soon after emergence, and moult within 3 days at 27°C (7 days at 15°C). Second-instar larvae are very active, often seeking concealed sites for feeding. A newly emerged female is relatively quiescent during her first 24 hours, but soon becomes active, particularly at higher temperatures. Females usually live about 40 days under laboratory conditions, but can survive as long as 90 days. Males live only half as long as females. Oviposition normally begins 72 h after emergence and continues intermittently throughout adult life. At 27°C, females lay a mean of 0.66 to 1.63 eggs per day, but McDonald *et al*. (1997) have demonstrated that adults and larvae of this species can survive sub-zero temperatures and still reproduce effectively. At low populations, male western flower thrips compete with each other by flicking at a rival with the apex of their abdomen such that only one or two males remain on a leaf, but at higher populations this competitive behaviour is less apparent (Terry, 1995). Copulation is not prolonged in this species. Males are haploid, produced from unfertilized eggs, whereas females are diploid and derive from fertilized eggs. Most populations have many more females than males, possibly because males have a shorter adult life, but it has yet to be determined how much control a mated female exerts over the sex of her offspring.

Various species of the worldwide anthocorid genus *Orius* are used in biological control against thrips, and these bugs are evidently important as predators in many natural populations. *Amblyseius cucumeris* is one of the most widespread mites used in attempts at the biological control of western flower thrips.

Economic importance: Thrips affect commercial plant production in various ways, directly by reducing yield and market quality, whether through feeding damage or by the transmission of virus diseases, but also indirectly when the mere presence of thrips on a crop is used as a reason for denying it entry to a profitable market.

In some crops, including rose flowers, strawberries, capsicums and cucumbers, it is the marketable product that is physically attacked by thrips resulting in direct losses due to down-grading. In other crops, attack is more insidious, whether due to leaf damage, or due to the introduction of tospoviruses leading to weaker plants and yield reductions. Sometimes entire crops are lost to virus attacks vectored by thrips, such as Impatiens in glasshouses, and lettuces out of doors. The worst attacks are commonly associated with poor crop hygiene, where a grower has failed to recognize the relationship between a susceptible crop and a weed as a source of infection. Indeed, all too frequently a susceptible crop can be seen newly planted alongside some other crop that is seriously infected but not yet harvested. In contrast, some careful growers mass produce even the most susceptible of crops, such as New Guinea Impatiens, with no losses due to thrips or tospoviruses because their attention to crop hygiene and glasshouse construction is so meticulous.

References:

Bryan, D.E. and Smith, R.F. (1956). The *Frankliniella occidentalis* complex in California. University of California, Publications in Entomology 10: 359-410.

CABI/EPPO (1998). *Frankliniella occidentalis*. Distribution Maps of Quarantine Pests for Europe No. 72. Wallingford, UK, CAB International.

EPPO (2004). PQR database (version 4.3). European and Mediterranean Plant Protection Organization, Paris, France.

Lublinkhof, J. and Foster, D.E. (1977). Development and reproductive capacity of *Frankliniella occidentalis* (Thysanoptera: Thripidae) reared at three temperatures. Journal of the Kansas Entomological Society 50: 313-316.

McDonald, J.R., Bale, J.S. and Walters, K.F.A. (1997). Effects of sub-lethal cold stress on the western flower thrips, *Frankliniella occidentalis*. Annals of Applied Biology 131: 189-195.

Terry, L.I. (1995). Competition in western flower thrips males: effects of density on behaviour, pp. 433-438. In: Parker, B.L., Skinner, M. and Lewis, T. (eds.) Thrips Biology and Management. Plenum Publishing, New York, USA.

2.2 PREDATORY MITES

2.2.1 Phytoseiid mites

Amblydromella rhenanoides (Athias-Henriot) [Acari: Phytoseiidae] – phytoseiid mite
Amblyseius aberrans (Oudemans) [Acari: Phytoseiidae] – phytoseiid mite
Amblyseius barkeri (Hughes) [Acari: Phytoseiidae] – phytoseiid mite
Amblyseius degenerans (Berlese) [Acari: Phytoseiidae] – phytoseiid mite
Amblyseius italicus Chant [Acari: Phytoseiidae] – phytoseiid mite
Amblyseius largoensis (Muma) [Acari: Phytoseiidae] – phytoseiid mite
Amblyseius potentillae (Garman) [Acari: Phytoseiidae] – phytoseiid mite
Amblyseius stipulatus Athias-Henriot [Acari: Phytoseiidae] – phytoseiid mite
Amblyseius swirskii Athias-Henriot [Acari: Phytoseiidae] – phytoseiid mite
Neoseiulus californicus McGregor [Acari: Phytoseiidae] – phytoseiid mite
Typhlodromus exhilaratus Ragusa [Acari: Phytoseiidae] – phytoseiid mite
Typhlodromus talbii Athias-Henriot [Acari: Phytoseiidae] – phytoseiid mite

Synonym(s):

Amblydromella rhenanoides (Athias-Henriot): *Typhlodromus rhenanoides* Athias-Henriot.

Amblyseius aberrans (Oudemans): *Kampimodromus aberrans* Oudemans.

Amblyseius barkeri (Hughes): *Neoseiulus barkeri* Hughes; *Typhlodromus barkeri* Hughes.

Amblyseius degenerans (Berlese): *Iphiseius degenerans* Berlese; *Seius degenerans* Berlese.

Amblyseius italicus Chant: none.

Amblyseius largoensis (Muma): *Typhlodromus largoensis* Muma; *Amblyseiopsis largoensis* Muma.

Amblyseius potentillae (Garman): *Amblyeiopsis potentiallae* Garman; *Typhlodromus pomi* Graman.

Amblyseius stipulatus Athias-Henriot: none.

Amblyseius swirskii Athias-Henriot: none.

Neoseiulus californicus McGregor: *Amblyseius californicus* (McGregor); *Typhlodromus californicus* McGregor.

Typhlodromus exhilaratus Ragusa: none.

Typhlodromus talbii Athias-Henriot: none.

Distribution:

Amblydromella rhenanoides (Athias-Henriot): France; Italy; Spain; USA (Oregon) (EPPO, 2004).

Amblyseius aberrans (Oudemans): Algeria; Austria; Bulgaria; France; Greece; Hungary; Italy; Netherlands; Portugal; South Africa; Spain; Switzerland; Ukraine; USA (Georgia, Oregon); USSR; Yugoslavia (EPPO, 2004).

Amblyseius barkeri (Hughes): Czech Republic; Denmark; Finland; Italy; Japan; Netherlands; South Africa; Spain; Turkey; USA (Florida, New York, Ohio); USSR (EPPO, 2004).

Amblyseius degenerans (Berlese): Burundi; Italy; Kenya; Malawi; Netherlands; Nigeria; Rwanda; South Africa; Spain; USA (California); Zimbabwe (EPPO, 2004).

Amblyseius largoensis (Muma): China; Costa Rica; Cuba; Italy; Papua New Guinea; Tanzania; Turkey; USA (EPPO, 2004; Vacante & Nucifera, 1986).

Amblyseius italicus Chant: Italy (Vacante *et al*., 1988).

Amblyseius potentillae (Garman): Canada; Germany; India; Italy; Netherlands; Poland; Turkey; USA (Mississippi); Yugoslavia (Vacante & Nucifera, 1986; EPPO, 2004).

Amblyseius stipulatus Athias-Henriot: Italy (Nucifera & Vacante, 1986).

Amblyseius swirskii Athias-Henriot: Egypt, Israel, Italy (EPPO, 2004; Vacante & Nucifera, 1986).

Neoseiulus californicus McGregor: Africa (as a whole); Argentina; China; Colombia; Cuba; Italy; Poland; Portugal; Spain; Switzerland; Taiwan; USA (EPPO, 2004).

Typhlodromus exhilaratus Ragusa: Italy; South Africa (EPPO, 2004).

Typhlodromus talbii Athias-Henriot: Italy (Vacante *et al*., 1988).

Host(s):

Amblydromella rhenanoides (Athias-Henriot): Fruits and leaves of all citrus species (Nucifera & Vacante, 1986); *Aculus fockeui*; *Cenopalpus lineola*; *Panonychus ulmi* (CABI, 2004).

Amblyseius aberrans (Oudemans): Lemon and orange leaves (Vacante & Nucifera, 1986); *Bryobia rubrioculus*; *Cenopalpus lineola*; *Eotetranychus carpini*; *Panonychus ulmi*; *Phytoptus avellanae;* (CABI, 2004).

Amblyseius barkeri (Hughes): Lemon and orange leaves (Vacante & Nucifera, 1986). Main prey are thrips including *Frankliniella occidentalis* (Pergande), *F. intosa* (Trybom), *Thrips tabaci* Lindeman, *T. palmi* Karny and *Parthenothrips dracaenae* (Hegeer) although the predator can survive on pollen (CABI, 2004).

Amblyseius degenerans (Berlese): Fruits and leaves of lemon, mandarin and oranges (Vacante & Nucifera, 1986). Main prey is *Frankliniella occidentalis* (Pergande). *Thrips tabaci* Lindeman is less favoured as prey. The predator will eat spider mites, *Tetranychus urticae* Koch, and can survive on pollen (CABI, 2004).

Amblyseius italicus Chant: Citrus (Vacante *et al*., 1988).

Amblyseius largoensis (Muma): *Tetranychus truncatus*, *Polyphagotarsonemus latus*, *Brevipalpus phoenicis*, *Oligonychus perditus* (CABI, 2004).

Amblyseius potentillae (Garman): *Diptacus gigantorhynchus*, *Aculus schlechtendali, Orthotydeus caudatus*, *Panonychus ulmi* (CABI, 2004).

Amblyseius stipulatus Athias-Henriot: *Panonychus ulmi*, *Aculus fockeui* and *Cenopalpus lineola* (CABI, 2004).

Amblyseius swirskii Athias-Henriot: *Aphis gossypii*, *Eutetranychus orientalis*, *Parabemisia myricae*, *Thrips tabaci*.

Neoseiulus californicus McGregor: This predatory mite is associated with several agricultural crops including strawberry, raspberries, roses, grapes, citrus, ornamentals and vegetables (Hoddle, 2000; Johnson & Lyon, 1991 Liburd *et al*., 2003; Rondon *et al*, 2004). *Calepitrimerus vitis* (grape leaf rust mite); *Eotetranychus carpini*; *Mononychellus* *progresivus*; *Oligonychus pratensis*; *Oligonychus punicae*; *Panonychus ulmi* (European red mite); *Polyphagotarsonemus latus* (broad mite) in Italy; *Tetranychus cinnabarinus* (carmine spider mite); *Tetranychus evansi*; *Tetranycopsis horridus* (CABI, 2004).

Typhlodromus exhilaratus Ragusa: *Colomerus vitis*; *Eotetranychus carpini*; *Panonychus ulmi* (CABI, 2004).

Typhlodromus talbii Athias-Henriot: *Panonychus citri*; *Aculops pelekassi*.

Biology: All phytoseiid mites have five life stages: the egg, a six legged larva, eight-legged protonymph and deutonymph stages and the adult (Sabelis, 1985). Development is typically quite rapid, with mean egg-to-egg developmental periods above 20°C being less than two weeks for almost all species (Tanigoshi, 1982) and successive generations are produced continually as long as conditions remain favourable. In temperate zones, short day lengths and relatively cool temperature induce a reproductive hibernal diapause in adult females after mating, which represent the only life stage that overwinters (Overmeer, 1985). Overwintering phytoseiid mites have collected mainly from fruit trees, where they are found in bark crevices and under insect scales (Kinsley & Swift, 1971; Ivancich-Gambro, 1990).

Diapause occurs only in adult females after mating and the most conspicuous characteristics of diapause is the failure of mated females to produce eggs (Overmeer, 1985). Diapausing females also tend to be less active than non-diapausing mites, feed rarely (Hoy & Flaherty, 1970; Rock *et al*., 1971; Wysoki, 1974; Van Houten *et al*., 1988; Morewood & Gilkeson, 1991) and are much more resistant to starvation when in diapause (Croft, 1971; Ivancich-Gambro, 1990). Phytoseiid mites generally diapause only after being exposed to diapause-inducing conditions throughout their juvenile development; however, a few species have been reported to 'switch' into diapause when exposed to diapause-inducing conditions as adults after being reared under non-diapause conditions (Hoy, 1975; Swift, 1987; Van Houten, 1989). The ability to diapause is not universal in phytoseiid mites; rather, some species and some populations within a species have been shown to lack a diapause response or to overwinter without diapausing (Wysoki & Swirski, 1971; McMurtry *et al*., 1976; Overmeer, 1985).

Predatory mites pierce their prey and suck the contents. They consume between 1 and 5 thrips per day depending on prey-instar, temperature and humidity, giving a total of about 85 in their lifetime. Female predatory mites lay between 22 (at 15 to 16°C) and 47 (at 25 to 26°C) eggs throughout their life. Eggs hatch after 2 or 3 days, followed by 4 days for immature development at 25°C. Adults live up to 30 days, depending on the temperature (CABI, 2004). *Amblyseius barkeri* can survive on pollen and can be introduced before the thrips populations build up. However, in crops that produce large quantities of pollen, its effectiveness is reduced because of this alternative food source so higher populations must be introduced. *Amblyseius barkeri* consumes first instar thrips larvae more readily than later instars (CABI, 2004).

Neoseiulus californicus lay eggs on the hairs in the axils of the midvein and the lateral veins on the underside of leaves (Malais & Ravensberg, 2003). The eggs hatch into six-legged larvae that do not feed and remain in groups near their place of emergence. Proto- and deutonymphal stages and adults have eight legs, are mobile and feed (CABI, 2004). The life-span of the adult is about 20 days (Krantz, 1978; McMurtry & Croft, 1997). The upper and lower temperature limits for *N. californicus* developmental range is between 10-33^{0}C (Malais & Ravensberg, 2003).

Neoseiulus californicus feed on phytophagous mites by piercing the prey and sucking the contents. It shows a feeding preference for the larval and nymphal stages of the two-spotted spider mite when the pest is present at low densities (Malais & Ravensberg, 2003). At 26°C, immature predatory mites consume on average 11.4 spider mite eggs and nymphs before reaching adulthood. An adult female can consume in excess of 150 prey over a 16 day period. Egg laying varies with temperature from less than one per day (to yield a total of 48 throughout female life cycle) at 13°C to over 3.5 per day (to yield a total of 65 throughout the female life cycle) at 33°C. Duration of development, egg laying and longevity will depend upon temperature, the type and availability of food and the ambient humidity. Development is more rapid at high temperature, taking about 15 days at 15°C, 8 days at 20°C and 5.5 days at 25°C. *Neoseiulus californicus* is particular useful where food is scarce, temperatures are high, humidity is low and when the phytophagous mites are concealed in the terminal shoots of the crop.

Economic importance: Generalist predators have the potential to damage non-target organisms (Howarth, 1991). Predacious mites interact interspecifically through competition for prey or feeding on each other (Croft & MacRae, 1993). Mutual predation reported among predatory mites could result in localised displacement of established mites in the natural ecosystem (Reitz & Trumble, 2002). *Amblyseius aberrans* has been recorded to displace *Typhlodromus pyri* (Duso *et al*., 1991). *Typhlodromus pyri* has been recorded to displace *Metaseiulus occidentalis* (Croft & McRae, 1993).

References:

CABI (2004). Crop Protection Compendium Global Module. CAB International, Wallingford, UK. http://www.cabicompendium.org/cpc/home.asp

Croft, B.A. (1971). Comparative studies on four strains of *Typhlodromus occidentalis* (Acarina: Phytoseiidae). V. Photoperiodic induction of diapause. Annals of Entomological Society of America 64: 962-964.

Croft, B.A. and MacRae, I.V. (1993). Biological control of apple mites by a phytoseiid mite complex and *Zetzellia mali* (Acari: Stigmaeidae) on *Typhlodromus pyri* and *Metaseiulus occidentalis* (Acari: Phytoseiidae). Environmental Entomology 22: 865-873.

Duso, C., Pasqualetto, C. and Camporese, P. (1991). Role of the predatory mites *Amblyseius aberrans* (Oud.), *Typhlodromus pyri* Scheuten and *Amblyseius andersoni* (Chant) [Acari: Phytoseiidae] in vineyards. II. Minimum releases of *A. aberrans* and *T. pyri* to control spider mites populations. Journal of Applied Entomology 112: 298-308.

EPPO (2004). PQR database (version 4.2). European and Mediterranean Plant Protection Organization, Paris, France.

Hoddle, M.S. (2000). Using *Neoseiulus californicus* for control of Persea mite. California Avocado Research Symposium. University of California Riverside.

Howarth, F.G. (1991). Environmental impacts of classical biological control. Annual Review of Entomology 36: 485-510.

Hoy, M.A. (1975). Diapause in the mite *Metasciulus occidentalis*: Stages sensitive to photoperiodic induction. Journal Insect Physiology 21: 605-611.

Hoy, M.A. and Flaherty, D.L. (1970). Photoperiodic induction of diapause in a predaceous mite, *Metaseiulus occidentalis*. Annals of Entomological Society of America 63: 690-693.

Ivancich Gambaro, P. (1990). Diapause in *Amblyseius andersoni* Chant (equals *Amblyseius potentillae* Garman) (Acarina: Phytoseiidae) in the climate of the Po Valley. Boll. Zool. Agr. Bachic. 22: 31-42.

Johnson, W.T. and Lynon, H.H. (1991). Insects that feed on trees and shrubs. 2nd Edition. Comstock Publishing Associates. 560 pp.

Knisley, C.B. and Swift, F.C. (1971). Biological studies of *Amblyseius umbraticus* (Acarina: Phytoseiidae). Annals of Entomological Society of America 64: 813-822.

Krantz. G.W. (1978). A manual of Acarology. Oregon State University, Corvallis, Oregon. 509 pp.

Liburd, O.E., Seferina, G.G. and Dinkins (2003). Suppression of two-spotted mites. In: UF/IFAS, Berry/Vegetable Times, November.

Malais, M.H. and Ravensberg, W.J. (2003). Knowing and recognizing: the biology of glasshouse pests and their natural enemies. Koppert B.V. and Reed Business Information, 288 pp.

McMurtry, J.A., Mahr, D.L. and Johnson, H.G. (1976). Geographic races in the predaceous mite, *Amblyseius potentillae* (Acari: Phytoseiidae). International Journal of Acarology 2: 23-48.

McMurtry, J.A. (1982). The use of phytoseiids for biological control: progress and future prospects, pp. 23-48. In: Hoy, M. (ed.) Recent advances in knowledge of the Phytoseiidae. University of California Press, Berkeley, Publication No. 3284.

Morewood, W.D. and Gilkeson, L.A. (1991). Diapause induction in the thrips predator *Amblyseius cucumeris* (Acarina: Phytoseiidae) under greenhouse conditions Entomophaga 36: 253-263.

Overmeer, W.P.J. (1985). Diapause, pp. 95-102. In: Helle, W. and Sabelis, M.W. (eds), Spider mites: Their biology, natural enemies and control. Vol. 1B. Elsevier, Amsterdam.

Reitz, S.R., and Trumble, J.T. (2002). Competitive displacement among insects and arachnids. Annual Review of Entomology 47: 435-465.

Rock, G.C. Yeargen, D.R. and Rabb, R.L. (1971). Diapause in the phytoseiid mite, *Neoseiulus fallacis*. Journal of Insect Physiology 17: 1651-1659.

Rondon, S.I., Price, J.F., Liburd, O.E., Francis, R. and Cantliffe, D.J. (2004). *Neoseiulus californicus* McGregor: A predatory mite species for controlling two-spotted spider mites in strawberries. HS 1001 Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu

Sabelis, M.W. (1985). Development 43-53 pp. In: Helle, W. and Sabelis, M. W. (eds), Spider mites: Their biology, natural enemies and control. Vol. 1B. Elsevier, Amsterdam.

Swift, F.C. (1987). Diapause induction in *Amblyseius fallacies* (Acari: Phytoseiidae). Environmental Entomology 16: 72-76.

Tanigoshi, L.K. (1982). Advances in knowledge of the biology of the Phytoseiidae, pp 1-22 In: Hoy, M.A. (ed) Recent Advances in Knowledge of the Phytoseiidae. Agricultural Sciences Publication 3284. University of California, Berkeley.

Vacante, V. and Nucifora, A. (1986). A first list of the mites in citrus orchards in Italy, pp 177-188. In: Cavalloro, R., and Di Martino, E. (eds.). Integrated Pest Control in Citrus-Groves: Proceedings of the experts' meeting, Acireale, 26-29 March 1985. Rotterdam, Netherlands: Published for the Commission of the European Community by A.A. Balkema, Rotterdam/Boston.

Vacante, V., Nucifora, A. and Garzia, G.T. (1988) Citrus mites in the Mediterranean area. Bulletin SROP 11: 39-49.

Van Houten, Y.M. (1989). Photoperiod control of adult diapause in the predacious mite, *Amblyseius potentillae*: Repeated diapause induction and termination. Physiological Entomology 14: 341-348.

Van Houten, Y.M., Overmeer, W.P.J., Van Zon, A.Q. and Veerman, A. (1988). Thermoperiodic induction of diapause in the predacious mite, *Amblyseius potentillae*. Journal of Insect Physiology 34: 285-290.

Wysoki, M. (1974). Studies on diapause and the resistance to low temperature of a predacious mite, *Phytoseius finitimus* (Mesostigmata: Phytoseiidae). Entomologie Experimentale Applicata 17: 22-30.

Wysoki, M. and Swirski, E. (1971). Studies on overwintering of predacious mites of the genera *Seiulus* Berlese and Phytoseius Ribaga in Israel (Acarina: Phytoseiidae). Israel Journal of Entomology 6: 55-70.

2.2.2 Stigmaeid mites

Eryngiopus bifidus Wood [Acari: Stigmaeidae] – stigmaeid mite

Eryngiopus siculus Vacante & Gerson [Acari: Stigmaeidae] – stigmaeid mite

Zetzellia collyerae (Gonzalez-Rodriguez) [Acari: Stigmaeidae] – stigmaeid mite

Zetzellia graeciana Gonzales [Acari: Stigmaeidae] – stigmaeid mite

Zetzellia mali (Ewing) [Acari: Stigmaeidae] – stigmaeid mite

Synonym(s):

Eryngiopus bifidus Wood: none.

Eryngiopus siculus Vacante & Gerson: none.

Zetzellia collyerae (Gonzalez-Rodriguez): *Agistemus collyerae* Gonzalez.

Zetzellia graeciana Gonzales: none.

Zetzellia mali (Ewing): *Caligonus mali* Ewing.

Distribution:

Eryngiopus bifidus Wood: Florida (Rakha & McCoy, 1984); Italy (Vacante & Nucifera, 1986).

Eryngiopus siculus Vacante & Gerson: Italy (Vacante & Gerson, 1987).

This genus has been reported in India (Krishnamoorty & Rajagopal, 1999); USA (Rakha & McCoy, 1984); Brazil (Zacaria, & José de Moraes, 2002); New Zealand (NZAC, 2004); China (Fan *et al*., 2000); South Africa (Marshall *et al*., 1999).

Zetzellia collyerae (Gonzalez-Rodriguez): Italy (Vacante & Nucifera, 1986).

Zetzellia graeciana Gonzales: Italy (Vacante & Nucifera, 1986).

Zetzellia mali (Ewing): China, Georgia, Iran, Austria, Bulgaria, USSR, Yugoslavia, France, Germany, Hungary, Italy, Canada, USA (CABI, 2004) and Israel (Jeppson *et al*., 1975).

Host(s):

Eryngiopus bifidus Wood: *Aonidiella aurantii* (Krishnamoorty & Rajagopal, 1999).

Eryngiopus siculus Vacante & Gerson: *Aonidiella aurantii* (Krishnamoorty & Rajagopal, 1999).

Zetzellia collyerae (Gonzalez-Rodriguez): Citrus (Vacante & Nucifera, 1986).

Zetzellia graeciana Gonzales: Citrus (Vacante & Nucifera, 1986); *Panonychus ulmi* (CABI, 2004).

Zetzellia mali (Ewing): Citrus (Vacante & Nucifera, 1986); tetranychid and eriophyid mites (Santos & Laing, 1985).

Biology: Stigmaeid mites are small to medium-sized mites. The life history consists of the egg, larva, protonymph, deutonymph and adult stages. Sperm transfer is by copulation as in spider mites. Sex determination is arrhenotoky; unfertilized eggs give rise to males only. Long distance dispersal is by wind. Mites of genera *Agistemus* and *Zetzellia* are commonly found on the foliage of higher plants (Zhang, 2003).

Stigmaeid mites are predators of phytophagous mites and feed on a variety of prey, including European red mite, two-spotted spider mite, rust mites, tydeid mites and scales (Weeden *et al*., 2005). Some species within the genera *Agistemus* and *Zetzellia* are important biological control agents. Stigmaeid mites also feed on pollen when prey population levels are low (Weeden *et al*., 2005). *Zetzellia mali* is a predator of the two-spotted spider, European red mite, the brown mite, and other mites on fruit trees in North America, Europe and Israel. This species by itself is usually not able to keep the tetranychid mites in check, but it is occasionally able to maintain populations of apple rust mite, *Aculus schlechtendali*, at low densities in the north-western United States (Jeppson *et al*., 1975).

Zetzellia mali is capable of feeding on several different types of prey including eggs and immature stages of tetranychid mites and eriophyid mites (Woolhouse & Harmsen, 1984; Santos & Laing, 1985), pollen, sap and fungal spores indicating that they have high survival rates at low prey densities (Clements & Harmsen, 1990). *Zetzellia mali* has a short generation time. Three to four generations per year have been reported (Solomon *et al*., 2000) and stigmaeid mites population cycles are linked with those of their prey (Solomon *et al*., 2000). When the favoured prey is scare, some species may survive by seeking alternative foods or by predation on their own or other phytoseiid species (McMurtry & Croft, 1997).

Economic importance: Predacious mites interact inter-specifically through competition for prey or feeding on each other (Croft & MacRae, 1993). Mutual predation reported among predatory mites could result in localised displacement of established mites in the natural ecosystem (Reitz & Trumble, 2002). *Zetzellia mali* is known to displace other mites including *Metaseiulus occidentalis* and *Typhlodromus pyri* (Croft & MacRae, 1993). *Zetzellia mali* does have a negative impact on phytoseiid mite populations and this impact is greater on some species of phytoseiids than others (Croft & MacRae, 1993).

References:

CABI (2004). Crop Protection Compendium Global Module. CAB International, Wallingford, UK. http://www.cabicompendium.org/cpc/home.asp

Clements, D.R. and Harmsen, R. (1990). Predatory behaviour and pre-stage preferences of stigmaeid and phytoseiid mites and their potential compatibility in biological control. Canadian Entomologist 122: 321-328.

Croft, B.A. and MacRae, I.V. (1993). Biological control of apple mites by a phytoseiid mite complex and *Zetzellia mali* (Acari: Stigmaeidae) on *Typhlodromus pyri* and *Metaseiulus occidentalis* (Acari: Phytoseiidae). Environmental Entomology 22: 865-873.

Fan, Q., Zhang, Y. and Liu, Q. (2000). Raphignathoid mites on bamboo from Fujian, China (Acari: Prostigmata). Systematic and Applied Acarology Special Publications, pp.49-68. http://www.nhm.ac.uk/hosted_sites/acarology/saas/saasp/pdf10/saasp04e.pdf

Jeppson, L.R., Keifer, H.H. and Baker, E.W. (1975). Mites Injurious to Economic Plants. University of California Press, Berkeley, USA.

Krishnamoorthy, A. and Rajagopal, D. (1999). Selection of host for mass production of California red scale. Insect Environment 5: 86-87.

Marshall, D.J., Gremmen, N.J.M., Coetzee, L., O'Connor, B.M., Pugh, P.J.A., Theron, P.D. and Ueckermann, E.A. (1999). New records of Acari from sub-Antarctic Prince Edward Islands. Polar Biology 21: 84-89.

McMurtry, J.A. and Croft, B.A. (1997). Life styles of phytoseiid mites and their role as biological control agents. Annual Review of Entomology 42: 291-321.

NZAC (2004). Landcare Research Database. Primary type specimens in the New Zealand Arthropod Collection (NZAC): Acari. Part 2: Alphabetical list by family. http://www.landcareresearch.co.nz/research/biodiversity/invertebratesprog/nzac/acar_fami.asp

Rakha, M.A. & McCoy, C.W. (1984). *Eryngiopus citri*, a new mite on Florida citrus with descriptions of the developmental stages (Stigmaeidae: Actinedida). Florida Entomologist 67: 504-507.

Reitz, S.R., and Trumble, J.T. (2002). Competitive displacement among insects and arachnids. Annual Review of Entomology 47: 435-465.

Santos, M.A., and Laing, J.E. (1985). Stigmaeid predators, pp. 197-203. In: Helle, W. and Sabelis, M.W. (eds), Spider mites: Their biology, natural enemies and control. Vol. 1B, Elsevier, Amsterdam.

Solomon, M.G., Cross, J.V., Fitzgerald, J.D., Campbell, C.A.M., Jolly, R.L., Olszak, R.W., Niemczyk, E. and Vogt, H. (2000). Biocontrol of pests of apples and pears in northern and central Europe – 3: Predators. Biocontrol Science and Technology 10: 91-128.

Vacante, V. and Gerson, U. (1987). Three species of *Eryngiopus* (Acari: Stigmaeidae) from Italy, with key to species and summary of habitats. Redia 70: 385-401.

Vacante, V. and Nucifora, A. (1986). A first list of the mites in citrus orchards in Italy, pp. 177-188. In: Cavalloro, R., and Di Martino, E. (eds.). Integrated Pest Control in Citrus-Groves: Proceedings of the experts' meeting, Acireale, 26-29 March 1985. Rotterdam, Netherlands: Published for the Commission of the European Community by A.A. Balkema, Rotterdam/Boston.

Weeden, C.R., Shelton, A.M., Li, Y. and Hoffmann, M.P. (2005). Biological control: A guide to natural enemies in North America. Cornell University. http://www.nysaes.cornell.edu/ent/biocontrol/

Woolhouse, M.E.J. and Harmsen, R. (1984). The mite complex on foliage of a pesticide-free apple orchard population dynamics and habitat association. Proceedings of Entomological Society of Ontario 115: 1-11.

Zacarias, M.S. and Moraes, G.J. (2002). Mite diversity (Arthropoda: Acari) on euphorbiaceous plants in three localities in the state of Sao Paulo. Biota Neotropica 2: 1-12. http://www.biotaneotropica.org.br

Zhang, Z.Q. (2003). Other beneficial mites, pp, 211-218. In: Mites of greenhouse: Identification, biology and control. CABI Publishing.

2.3 PATHOGENS

2.3.1 Brown rot

Phytophthora palmivora (E.J. Butler) E.J. Butler

Phytophthora syringae (Kleb.) Kleb.

Synonym(s):

Phytophthora palmivora (E.J. Butler) E.J. Butler: *Phytophthora arecae* (L.C. Coleman) Pethybr.; *Phytophthora cactorum* var. *arecae* (L.C. Coleman) Sacc. & Trotter; *Phytophthora faberi* Maubl.; *Phytophthora heveae* A.W. Thompson; *Phytophthora omnivora* var. *arecae* L.C. Coleman; *Phytophthora palmivora* var. *heveae* (A.W. Thompson) Orellana; *Phytophthora palmivora* var. *theobromae* (L.C. Coleman) Orellana; *Phytophthora theobromae* L.C. Coleman. *Pythium palmivorum* E.J. Butler.

Phytophthora syringae (Kleb) Kleb.: *Phloeophthora syringae* Kleb.; *Ovularia syringae* Berk.; *Nozemia syringae* (Kleb.) Pethybr.

Common name(s):

Phytophthora palmivora (E.J. Butler) E.J. Butler: brown rot.

Phytophthora syringae (Kleb.) Kleb.: brown rot.

Host(s):

Phytophthora palmivora (E.J. Butler) E.J. Butler: Primary hosts include: *Areca catechu* (betelnut palm); *Carica papaya* (pawpaw); *Cocos nucifera* (coconut); *Dimocarpus longan* (longan); *Hevea brasiliensis* (rubber); *Litchi chinensis* (lychee); and *Theobroma cacao* (cocoa). Secondary hosts include: *Anacardium occidentale* (cashew nut); *Ananas comosus* (pineapple); *Annona muricata* (soursop); *Annona glabra* (pond apple); *Areca* sp. (areca palm); *Artocarpus altilis* (breadfruit); *Citrus* spp. (citrus); *Citrus* x *paradisi* (grapefruit);

Durio zibethinus (durian); *Elaeis guineensis* (African oil palm); *Ficus carica* (common fig); *Gossypium hirsutum* (cotton); *Mangifera indica* (mango); *Manihot esculenta* (cassava); *Manilkara zapota* (sapodilla); *Myristica fragrans* (nutmeg); Palmae (plants of the palm family); *Persea americana* (avocado); *Piper nigrum* (black pepper) (CABI, 2004; Ploetz *et al*., 2003).

Phytophthora syringae (Kleb.) Kleb.: *Aesculus hippocastanum*; *Alnus glutinosa*; *Castanea saliva*; *Cereus martianus*; *Cereus tetracanthus*; *Chionanthus viriginica*; *Citrus* spp.; *Corylus avellanae*; *Crataegus oxyaxantha*; *Foeniculum vulgae*; *Jasminum nudiflorum*; *Ligustrum vulgare*; *Malus domestica*; *Prunus armeniaca*; *Prunus cerasus*; *Prunus domestica*; *Prunus persica*; *Pyrus communis* and *Quercus* spp. (Waterhouse & Waterston, 1964).

Plant part(s) affected: Fruit, leaf, root, young shoots (Brown, 2003; Coates *et al*., 2003).

Distribution:

Phytophthora palmivora (E.J. Butler) E.J. Butler: Afghanistan; Angola; Argentina; Australia (Northern Territory; Queensland); Belize; Bolivia; Brazil; Brunei Darussalam; Cameron; Central African Republic; China; Congo; Costa Rica; Cuba; Dominica; Ecuador; El Salvador; Fiji; France; Gabon; Ghana; Greece; Grenada; Guatemala; Guinea; Guyana; Haiti; Honduras; India; Indonesia; Iran; Italy; Ivory Coast; Jamaica; Jordan; Lebanon; Liberia; Madagascar; Malawi; Malaysia; Mauritius; Mexico; Morocco; Myanmar; New Caledonia; Nicaragua; Nigeria; Panama; Papua New Guinea; Peru; Philippines; Puerto Rico; Reunion; Saint Lucia; Samoa; Senegal; Sierra Leone; Singapore; Solomon Islands; Somalia; Spain; Sri Lanka; Suriname; Tanzania; Thailand; Togo; Tonga; Trinidad and Tobago; USA (Arizona, California, Florida, Hawaii); Vanuatu; Venezuela; Zimbabwe (CABI, 2004).

Phytophthora syringae (Kleb.) Kleb.: Australia (South Australia); Belgium; Canada; Czech Republic; Denmark; Germany; Greece; Great Britain; France; Holland; India; Italy; New Zealand; Portugal; Romania; Slovakia Republic; USA (Florida); USSR; Yugoslavia (Waterhouse & Waterston, 1964; Timmer *et al*., 2000; APPD; 2004).

Biology: *Phytophthora* species cause the most serious and economically important soil borne diseases of citrus. Tree and crop production losses occur from damping-off of seedlings in the seedbed, root and crown rot in nurseries, foot rot and fibrous root rot, and brown rot of fruit in groves.

Damping-off can affect newly germinated seedlings of all citrus cultivars. Typical symptoms of damping-off result when the soil or seed-borne fungus penetrates the stem just above the soil line and causes the seedling to topple. *Phytophthora* spp. also cause seed rot or pre-emergence rot. Infected seedlings are killed rapidly when moisture is abundant and temperatures are favorable for fungal growth. Plants usually become resistant to damping-off once the true leaves have emerged and the stem tissue at the soil line has matured (Graham & Timmer, 2003).

The most serious diseases caused by *Phytophthora* spp. are foot rot and gummosis. Foot rot results from an infection of the scion near the ground level, producing lesions which extend down to the bud union on resistant rootstocks. Citrus gum, which is water-soluble, disappears after heavy rains but is persistent on the trunk under dry conditions. Lesions spread around the circumference of the trunk, slowly girdling the tree. Badly affected trees have pale green leaves with yellow veins, a typical girdling effect. If the lesions cease to expand or the fungus dies, the affected area is surrounded by a callus tissue (Graham & Timmer, 2003).

Phytophthora spp. also attack and cause the decay of fibrous roots especially on susceptible rootstocks in nurseries. In bearing groves, fibrous root rot damage causes tree decline and yield losses. *Phytophthora* spp. infects fruit causing brown rot that leads to fruit drop in the groves and postharvest decay (Graham & Timmer, 2003).

Nursery trees and young orchard trees of small trunk circumference can be rapidly girdled and killed. Large trees may be killed likewise, but typically the trunks are partially girdled and the tree canopy undergoes defoliation, twig dieback, and short growth flushes. On susceptible rootstocks, lesions may occur on the crown roots below the soil line and symptoms in the canopy develop without obvious damage to the trunk aboveground.

Phytophthora spp. infects the root cortex and cause a decay of fibrous roots. The cortex turns soft, becomes somewhat discoloured, and appears water soaked. The fibrous roots slough their cortex leaving only the white thread-like stele, which gives the root system a stringy appearance (Graham & Timmer, 2003).

Root rot can be especially severe on susceptible rootstocks in infested nursery soil. Root rot also occurs on susceptible rootstocks in bearing orchards where damage causes tree decline and yield losses. In advanced stages of decline, the production of new fibrous roots cannot keep pace with root death. The tree is unable to maintain adequate water and mineral uptake, and nutrient reserves in the root are depleted by the repeated fungal attacks. This results in the reduction of fruit size and production, loss of leaves, and twig dieback of the canopy.

Phytophthora infection of fruit produces a decay in which the affected area is light brown, leathery, and not sunken compared to the adjacent rind. White mycelium forms on the rind surface under humid conditions. In the orchard, fruit near the ground become infected when splashed with soil containing the fungus. If favorable conditions of optimum temperature (22-28°C) and long periods of wetting (18 plus hours) continue, the disease spreads to fruit throughout the canopy. Most of the infected fruit soon abscise, but those that are harvested may not show symptoms until after they have been held in storage a few days. If infected fruit is packed brown rot may spread to adjacent fruit in the container. In storage, infected fruit have a characteristic pungent, rancid odour. Brown rot epidemics are usually restricted to areas where rainfall coincides with the early stages of fruit maturity. All cultivars are affected, especially lemons (Graham & Timmer, 2003).

Fungal populations in the soil are maintained by repeated infection of the fibrous roots. Under favorable conditions of high moisture and temperature infected roots produce sporangia which in turn release motile zoospores. Zoospores are attracted to the zone of elongation of new roots by nutrients in exudations. Upon contact with the root zoospores encyst, germinate and then infect in the area of the zone of root elongation. Once the fungus has entered the root tip the infection may advance in the cortex resulting in rot of the entire rootlet. The cycle can repeat itself as long as conditions are favorable and susceptible tissue is available (Graham & Timmer, 2003).

Foot rot or gummosis of the trunk occurs when zoospores or other propagules are splashed onto the trunk above the bud union. A wound and moisture on or around the base of the trunk are necessary for infection. Wounds are susceptible to infection for up to 14 days. Foot rot lesions do not usually produce inoculum for subsequent infections and, thus, are of no epidemiologic significance (Graham & Timmer, 2003).

The primary means by which *Phytophthora* spp. are spread through citrus orchards is by use of infested nursery stock. The pathogen may be present in soil or infected roots even though disease symptoms are not readily apparent. The fungus is also carried in soil on equipment when vehicles move from infested to non-infested groves or nurseries. Propagules densities decline sharply when soil is air-dried, reducing the probability of spread (Graham & Timmer, 2003).

Irrigation water may also move the pathogen from area to area. Within groves, dispersal by irrigation water occurs especially where furrow or flood irrigation is used. Surface water following heavy rains may carry the fungus as it drains from the grove. More serious problems can arise in irrigated citrus areas where run-off water carries the pathogen into canals, or ponds. Use of water from these sources may then contaminate previously non-infested areas (Graham & Timmer, 2003).

Wind is not a major factor in dispersal of *Phytophthora* spp. However, wind-borne soil carries *Phytophthora* spp. and may recontaminate fumigated soils. Windblown rain can disseminate sporangia produced on the surface of aboveground plant parts (Graham & Timmer, 2003).

P. palmivora can survive dry periods as dormant chlamydospores, oospores or dormant mycelium, and produce sporangia and zoospores when the rain returns. Chlamydospores are also found in fruit tissue and are most important survival structure (CABI, 2004).

In cocoa, the whole plant is attacked resulting in pod rot, bark and stem and cushion canker, wilt and blight. Circular brown lesions develop on pods eventually blackening and mummifying the pod sometimes covered in a white mass of sporangia (CABI, 2004). Low initial inoculum can build up rapidly by repeated cycles of sporangia and zoospores production due to a very short regeneration time. Above ground sources of infection such as mummified pods, infected flowers and cankers are important for primary infection with rain splash on the soil and diseased pods and leaves creating droplets which move upwards with convection and can also be moved by insect vectors such as ants. Cankers can also form in wounds after insect injury (CABI, 2004). Rain splash is also responsible for transmission of rubber leaf disease and papaya root rot liberating sporangia from infected leaves and fruit and from soil into the air. Wind dispersal of inoculum and windblown rain permits spread and developments of epidemics (CABI, 2004).

Economic importance: Recent estimates attribute 44% of the total global crop loss of cocoa to black pod disease (Van der Vossen, 1997). *P. palmivora* is a serious pathogen in West Africa where over 60% of global cocoa is produced. Pod rot and stem canker caused cocoa pod losses of up to 63% and the death of up to 10% of trees annually on Kar Kar Island, Papua New Guinea (Guest *et al.*, 1994). There were substantial losses due to papaya root rot in south-eastern Queensland in the 1950s and more than 20% of plants were destroyed in one papaya plantation in central Taiwan in 1975 (Ko, 1994). Pineapple heart rot is a problem in Australia, the Philippines, South Africa and Thailand, but worldwide losses are highly variable (CABI, 2004).

References:

APPD (2004). Australian Plant Pest Database. Plant Health Australia. http://www.planthealthaustralia.com.au/APPD/queryForm.asp

Brown, G.E. (2003). Brown rot: Causal organisms and disease cycle. pp. 33. Plant Pathology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu/CH109

CABI (2004). Crop Protection Compendium (2004 edition). CAB International, Wallingford, UK.

Coates, L.M., Sangchote, S., Johnson, G.I. and Sittigul, C. (2003). Diseases of lychee, longan and rambutan. In: Ploetz, R.C. (ed.) Diseases of Tropical Fruit Crops. CABI Publishing, Wallingford, UK. pp. 307-325.

Guest, D.I., Anderson, R.D., Foard, H.J., Phillips, D., Worboys, S. and Middleton, R.M. (1994). Long-term control of *Phytophthora* diseases of cocoa using trunk-injected phosphonate. Plant Pathology 43: 479-492.

Graham, J.H. and Timmer. L.W. (2003). Phytophthora diseases of citrus. SL 127. Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu/CH087

Ko, W.H. (1994). *Phytophthora* fruit and root rot. pp. 61-62. In: Ploetz, R.C., Zentmeyer, G.A., Nishijima, W.T, Rohrbach, K.G. and Ohr, H.D. (eds), Compendium of Tropical Fruit Diseases. American Phytopathological Society (APS) Press, St Paul, Minnesota, USA.

Ploetz, R.C., Lim, T.K., Menge, J.A., Kenneth, G., Rohrbach, K.G. and Michaolides, T.J. (2003). Common pathogens of tropical fruit crops, pp. 19. In: Ploetz, R.C. (ed.) Diseases of Tropical Fruit Crops. CABI Publishing, Wallingford, UK.

Timmer, L.W., Garnsey, S.M. and Graham, J.H. (2000). Compendium of citrus diseases. 2nd edition. APS Press, USA.

Van der Vossen, H.A.M. (1997). Strategies of variety improvement in cocoa with emphasis on durable disease resistance. pp. 9-18. International Group for Genetic Improvement of Cocoa.

Waterhouse, G.M. and Waterston, J.M. (1964). *Phytophthora syringae*. CMI Descriptions of Pathogenic Fungi and Bacteria No. 32. CABI International.

2.3.2 Dry rot

Nematospora coryli Peglion

Synonyms: *Eremothecium coryli* (Peglion) Kurtzman

Common name(s): dry rot of citrus.

Host(s): *Anacardium occidentale*; *Cajanus cajan*; *Citrus* spp.; *Coffea* spp.; *Corylus avallana* (filbert); *Crotalaria* spp.; *Dolichos lablab*; *Glycine max* (soybean); *Gossypium hirsutum*; *Lycopersicon esculentum*; *Phaseolus* (beans); *Pistacia vera* (pistachio); *Macadamia intregrifolia* (macadamia); *Tephrosia vogelii* and *Vigna sinensis* (CABI, 2004; Mukerji, 1968; Shivas *et al*., 2005).

Plant part(s) affected: Fruit, seed (Shivas *et al*., 2005).

Distribution: Australia (Queensland and New South Wales); Brazil; Central African Republic; China; Congo; Costa Rica; Cuba; Ethiopia; Gambia; Greece; Grenada; India; Indonesia; Iran; Iraq; Italy; Jamaica; Japan; Kenya; Madagascar; Malawi; Mexico; Myanmar; Nigeria; Philippines; Puerto Rico; Sri Lanka; South Africa; Tanzania; USA (California, Florida, Georgia, Illinois, Kansas, Maryland, Mississippi, North Carolina, Oklahoma, Oregon, South Carolina, Virginia); Uganda; Zambia and Zimbabwe (CABI, 2004; Shivas *et al*., 2005).

Biology: Information on *N. coryli* (insect-transmitted yeast) is limited and nothing is known about the aetiology or epidemiology of citrus dry rot in Australia. In 2004, *N. coryli* was isolated from seeds and fruits of *Citrus reticulata* (mandarin cv. de Nules), *Citrus limon* (lemon) and *Citrus australis* (native lime) from several locations in eastern Australia and identified for the first in Australia (Shivas *et al*., 2005). The insect-transmitted yeast was associated with dry rot in cultivated *Citrus* fruits. Symptoms of dry rot include dry flesh and brownish discoloured, shrivelled seeds (Shivas *et al*., 2005). It was reported to have been present and undetected in Queensland for at least ninety years (Shivas *et al*., 2005).

Nematospora coryli causes a serious disease on a range of plant species including varieties of *Citrus* (Fawcett, 1936; Shivas *et al*., 2005). It was reported to cause desiccation, dry rot and premature fruit drop of oranges, grapefruit and tangerines in California in the 1920s (Fawcett, 1929). However, recent literature fails to report *N. coryli* as a pathogen of *Citrus* spp. (Reuther *et al*., 1978; Timmer *et al*., 2000). *Nematospora coryli* is known as a serious pathogen of seeds of many species of tropical and sub-tropical plants, including *Gossypium hirsutum* (where it is the cause of internal boll rot or stigmatomycosis), *Anacardium occidentale*, *Coffea* spp., *Corylus avallana*, *Crotalaria* spp., *Cajanus cajan*, *Phaseolus* spp. and *Vigna sinensis* (Mukerji, 1968).

The fungus is usually transmitted by sap-sucking pentatomid (Hemiptera) insects and it enters the plant through insect wounds (Mukerji, 1968). The yeast survives in adults through the insect’s life (Kulik & Sinclair, 1993). *Nematospora coryli* has been recorded in Africa, Asia, Europe and North and South America. The detection of *N. coryli* on native lime poses the intriguing prospect that it is a native of Australia and has moved onto cultivated citrus (Shivas *et al*., 2005).

Nematospora coryli has characteristic cylindrical-obtuse asci, 57-68 x 6-9 µm, each containing 4-8 needle-shaped ascospores, 40-50 x 2 µm. Ascospores are two-celled with long, slender, whip-like appendages. Spores are arranged in two groups within the ascus (Shivas *et al*., 2005). Growth in culture for 7 days resulted in white to cream colonies (Shivas *et al*., 2005). The fungus was readily found in the pulp, remote from the seed, of affected citrus fruits (Shivas *et al*., 2005).

Nematospora coryli is a pest of quarantine importance to the Caribbean (Schotman, 1989).

References

CABI (2004). Crop Protection Compendium (2004 edition). CAB International, Wallingford, UK.

Fawcett, H.S. (1926). *Nematospora* on pomegranates, citrus and cotton in California. Phytopathology 19: 479-482.

Fawcett, H.S. (1936). Citrus diseases and their control. McGraw-Hill: New York.

Kulik, M.M. and Sinclair, J.B. (1993). Yeast spot (*Nematospora* spot). In Compendium of soybean diseases. APS Press, USA.

Mukerji, K.G. (1968). *Nematospora coryli*. CMI descriptions of plant pathogenic fungi and bacteria 184.

Reuther, W., Calavan, E.C. and Carman, G.E. (1978). The citrus industry. Vol. IV. Crop Protection. University of California: Berkeley, CA, USA.

Schotman, C.Y.L. (1989). Plant pests of quarantine importance to the Caribbean. RLAC-PROVEG 21. Caribbean Plant Protection Commission, Port-of-Spain, Trinidad and Tobago.

Shivas, R.G., Smith, M.W., Marney, T.S., Newman, T.K., Hammelswang, D.L., Cooke, A.W., Pegg, K.G. and Pascoe, I.A. (2005). First record of *Nematospora coryli* in Australia and its association with dry rot of *Citrus*. Australasian Plant Pathology 34: 99-101.

Timmer, L. W., Garnsey, S. M. and Graham, J. H. (2000). Compendium of citrus diseases. 2nd edition. APS Press, USA.

2.3.3 Mal secco

Phoma tracheiphila (Petri) Kantachveli & Gikachvili – mal secco; citrus wilt

Synonym(s): *Deuterophoma tracheiphila* Petri; *Bakerophoma tracheiphila* (Petri) Cif.

Host(s): Almost all citrus plants are susceptible to artificial infections of *P. tracheiphila*. In the field, hybrids of citrus, related genera (*Eremocitrus*, *Fortunella*, *Poncirus* and *Severinia*) and other species have different degrees of resistance to the disease (CABI, 2004). Most cultivars of oranges, mandarins (*Citrus deliciosa* and *C. reticulata*), clementines and grapefruit are only occasionally affected (CABI, 2004). However, there are reports indicating that some mandarins (Palm, 1987; Solel & Salerno, 2000) and some of its hybrids (Punithalingam & Holliday, 1973) and Bergamot, tangelos, and tangors are quite vulnerable (Solel & Salerno, 2000). Infection of grapefruit and sweet orange is rare and usually not severe (Solel & Salerno, 2000). A number of rootstocks such as *C. reshni*, *Poncirus trifoliata* and, to a lesser extent, *C. sinensis* x *P. trifoliata* have been reported to be resistant (CABI, 2004).

Major hosts include *Citrus aurantifolia* (lime), *Citrus aurantium* (sour orange), *Citrus bergamia* (bergamot), *Citrus limon* (lemon), and *Citrus medica* (citron), whereas *Fortunella* (kumquat) and *Poncirus* are minor hosts (CABI, 2004).

Distribution: The presence of *Phoma tracheiphila* in Uganda and Colombia has been reported, but such records are considered doubtful (CABI, 2004). Albania; Algeria; Cyprus; France; Georgia (Republic); Greece; Iraq; Israel; Italy; Lebanon; Southern Russia; Syria; Tunisia; Turkey; Yemen (EPPO, 2002).

Biology: The fungus enters through wounds, and penetration through stomata is questioned (Perrotta & Graniti, 1988). Cultivation practices, wind, frost and hail that cause injuries to different organs favour infection by this fungus. Inoculum could be provided both by conidia produced from pycnidia present on withered twigs, and by conidia produced from phialides borne on free hyphae on exposed woody surfaces of the tree or on debris. Inoculum is believed to be waterborne (Solel, 1976). The range of temperature at which infection will occur is considered to be between 14 and 28°C. The optimum temperature for growth of the pathogen and for symptom expression is 20-25°C. The maximum temperature for mycelial growth is 30°C. In the Mediterranean region, infection periods depend on local climatic and seasonal conditions. In Sicily, infections usually occur between September and April (Somma & Scarito, 1986a, b).

The first symptoms appear in spring as leaf and shoot chlorosis, followed by a dieback of twigs and branches. Raised black points within lead gray or ash gray areas of withered twigs indicate the presence of pycnidia. The growth of sprouts from the base of the affected branches and suckers from the rootstock are a common response of the host to the disease. Gradually, the pathogen affects the entire tree, which eventually dies. On cutting into the infected twigs, the characteristic salmon-pink or orange-red discoloration of the wood can be seen. This internal symptom is associated with gum production within the xylem vessels (Magnano *et al*., 1992).

Destructive outbreaks of *Phoma tracheiphila* may occur after frost spells and hail storms in spring (Perrotta & Graniti, 1988). In addition to the more common form of mal secco, two different forms of the disease can be distinguished. Mal fulminante is a rapid fatal form of the disease apparently due to root infection. Mal nero is a consequence of chronic infection of the tree leading to a browning of the heartwood. The length of the incubation period may vary according to the season (Grasso & Tirrò, 1984). Conidia produced on the surface of wounds following pruning of infected twigs or branches can provide a source of inoculum for several weeks (Perrotta & Graniti, 1988). The fungus can survive within infected twigs in the soil for more than 4 months (De Cicco *et al*., 1987).

Short-distance dispersal of *Phoma tracheiphila* inoculum is caused by wind and rain (Laviola & Scarito, 1989). Birds and insects are also suspected to be vectors of the disease. Long-distance spread of this pathogen occurs through the movement of infected propagative material and plants. *Phoma tracheiphila* has been detected in lemon seeds (Stepanov & Shaluishkina, 1952). There is no evidence that it is seed-borne in other citrus species.

Economic importance: In the Mediterranean region, *P. tracheiphila* is the most destructive fungal disease of lemons. Up to 100% of trees in a lemon orchard of a susceptible cultivar can be affected. In general, injury to the tree through severe cold weather may predispose it to fungal attack. The symptoms of the disease are most severe in spring and autumn. In high summer temperatures, spread of the fungus in the host’s vascular system ceases and the symptoms do not develop further (Ruggieri, 1953). The disease reduces the quantity and quality of lemon production in the areas where the pathogen is present, and limits the use of susceptible species and cultivars.

References:

CABI (2004). Crop Protection Compendium. CAB International, Wallingford, UK.

De Cicco, V., Ippolito, A. and Salerno, M. (1987). Duration of the infective capacity of soil containing mal secco infected lemon twigs, pp. 175-176. Proceedings of the 7th Congress of the Mediterranean Phytopathological Union, Granada, Spain, 20-26 September 1987.

EPPO (2002). PQR database (version 4.1). European and Mediterranean Plant Protection Organization, Paris, France.

Grasso, S. and Tirrò, A. (1984). Observations on the seasonal susceptibility of lemons to infection by mal secco. Rivista di Patologia Vegetale 20: 13-19.

Laviola, C. and Scarito, G. (1989). Distance and direction of dissemination of *Phoma tracheiphila* (Petri) Kanc. et Ghik. propagules. Phytopathologia Mediterranea 28: 161-163.

Magnano, S.L.G., Cacciola, S.O., Pane, A. and Grasso, S. (1992). Relationship between xylem colonization and symptom expression in citrus mal secco disease. VII International Citrus Congress, Acireale, Italy, 8-13 March 1992.

Palm, M.E. (1987). Pests not known to occur in the United States or of limited distribution. No. 91. *Phoma tracheiphila*, APHIS-USDA.

Perrotta, G. and Graniti, A. (1988). *Phoma tracheiphila* (Petri) Kantschaveli et Gikashvili, pp 396-398. In: Smith, I.M., Dunez, J., Lelliot, R.A., Phillips, D.H. and Archer, S.A. (eds.). European Handbook of Plant Diseases. Blackwell Scientific Publications, Oxford, UK.

Punithalingam, E. and Holliday, P. (1973). *Deuterophoma tracheiphila* (Petri) Kantschaveli et Gikashvili. CMI Description of pathogenic fungi and bacteria. No 399.

Ruggieri, G. (1953). Periodicity of infection by mal secco and main strategies of control. Giornale di Agricoltura 34.

Solel, Z. (1976). Epidemiology of mal secco disease of lemons. Phytopathologische Zeitschrift 85: 90-92.

Solel, Z. and Salerno, M. (2000). Mal Secco. In: Compendium of Citrus Diseases. Timmer, L.W., Garnsey, S.M. and Graham, J.H. (eds). pp. 33-35. American Phytopathological Society, St Paul, Minnesota.

Somma, V. and Scarito, G. (1986a). Further researches on the periodicity of infections by *Phoma tracheiphila* in Sicily and preliminary observations on the incubation period of 'mal secco' disease of citrus. Giornate Fitopatologiche 2: 115-124.

Somma, V. and Scarito, G. (1986b). Three years of observations on the periodicity of *Phoma tracheiphila* (Petri) Kantschaveli et Gikashvili infections in Sicily. Phytopathologia Mediterranea 25: 103-106.

Stepanov, K.M. and Shaluishkina, V.I. (1952). Lemon fruit and seeds - sources of initial infectious desiccation. Microbiology Moscow 28: 48-51.

2.3.4 Septoria spot

Septoria citri Pass.

Common name(s): septoria spot, leaf spot.

Host(s): *Citrus* spp. (CABI, 2004).

Plant part(s) affected: Fruit, leaf, twigs (Timmer *et al*., 2000; Adaskaveg *et al*., 2004).

Distribution: Australia (excluding Western Australia); Argentina; Greece; India; Israel; USA (California) (Adaskaveg *et al*., 2004; CABI, 2004).

Biology: Leaf and fruit spots caused by *Septoria* spp. are generally considered of minor importance. Nevertheless, damage to fruit rind can cause concern where the appearance of fresh fruit is important. Lemons and grapefruit appear to be damaged more than other citrus, including oranges (Adaskaveg *et al*., 2004; Timmer *et al*., 2000).

At least 18 species of *Septoria* are reported to be associated with citrus leaf and fruit spots of citrus; however, none has been extensively studied (Emmett & Menge, 1988). The identification of species of *Septoria* on citrus depends on morphology, particularly pycnidial size, conidial length, and number of septa per conidium (Emmett & Menge, 1988; Bonde *et al*., 1991). These characteristics are extremely variable and, indeed, variation within a single isolate can span the reported ranges for several species (Emmett & Menge, 1988; Pugsley, 1939).

Several *Septoria* spp., including *S. citri*, *S. depressa* and *S. limonum* have been reported to cause Septoria spot (Bonde *et al*., 1991). Bonde *et al*. (1991) compared cultural isolates from Australia and the United States and they concluded that there was no detectable variation among isolates for most of the biochemical characteristics used in the evaluation. From this it was concluded that there was only one *Septoria* sp. involved in the disease – *Septoria citri*.

Disease symptoms occur on twigs, leaves and fruit of citrus (Adaskaveg *et al*., 2004). On leaves, lesions 1 to 4 mm in diameter develop as raised blister-like black spots that are surrounded by a yellow halo (Adaskaveg *et al*., 2004). Symptoms on fruit include circular, dark, and sunken spots 1 to 2 mm in diameter that may be surrounded by a reddish brown halo as fruit mature (Adaskaveg *et al*., 2004). Lesions are generally shallow and remain in the flavedo (oil–gland layer) but may turn into larger pitted lesions (4-6 mm in diameter) that extend into the albedo (white portion of the peel) (Adaskaveg *et al*., 2004). Infection may begin when the fruit is still green, but the symptoms do not become conspicuous until the fruit colours. Small black pycnidia (flask-shaped structures) may be produced in lesions (Whiteside *et al*., 1988). During storage, the originally small and inconspicuous spots can enlarge and coalesce to form brown to black blotches.

Septoria citri produces conidia in pycnidia on dead branches of citrus trees and within leaf and fruit lesions (Adaskaveg *et al*., 2004). During cool, wet weather or sprinkler irrigation, spores may be disseminated onto leaves and fruit by splashing water, where the spores can directly infect leaf tissue or fruit rind. Infections may remain quiescent until the plant tissue becomes senescent or the natural resistance of the host is lowered from environmental injury such as frost or cold damage (Adaskaveg *et al*., 2004).

Septoria spot can be managed in the grove through the use of protective fungicides – copper- or zinc-based materials applied to leaves and fruit prior to favourable environments for disease development (Adaskaveg *et al*., 2004).

References

Adaskaveg, J.E., O'Connell, N., Freeman, M., Kallsen, C., Mauk, P. and Faber, B. (2004). Citrus Notes: 1. University of California Cooperative Extension.

Bonde, M.R., Peterson, G.L., Emmett, R.W. and Menge, J.A. (1991). Isozyme comparisons of *Septoria* isolates associated with citrus in Australia and the United States. Phytopathology 81: 517-521.

CABI (2004). Crop Protection Compendium (2004 edition). CAB International, Wallingford, UK.

Emmett, R.W. and Menge, J.A. (1988). *Septoria* species of citrus in Australia and the United States. Report of the Australian Department of Agriculture and Rural Affairs. 245 pp.

Pugsley, A.T. (1939). A Septoria spot disease of citrus. Journal of Australian Institute of Agricultural Sciences 5: 106-108.

Timmer, L.W., Garnsey, S M. and Graham, J H. (2000). Compendium of citrus diseases. 2nd edition. APS Press, USA.