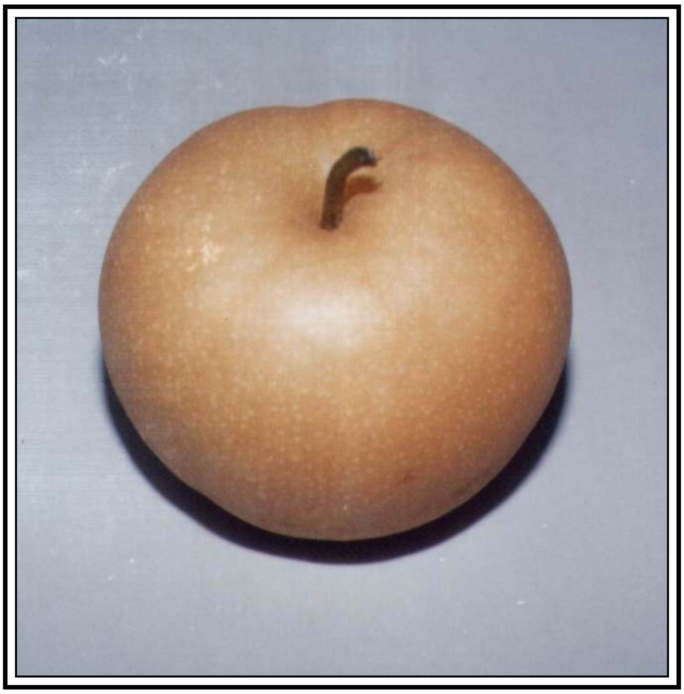
Import Risk Analysis: Pears (Pyrus bretschneideri, Pyrus pyrifolia, and *Pyrus* sp. nr. *communis)* fresh fruit from China

Final



Pyrus pyrifolia (Asian pear)
Photograph supplied by AQSIQ

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Policy and Risk
MAF Biosecurity New Zealand

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FINAL VERSION

30 October 2009

Approved for general release

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Executive summary

New Zealand currently imports Ya pears (*Pyrus bretschneideri*), from the People's Republic of China (Hebei and Shandong Provinces). China has requested access to the New Zealand market for a wider range of pear species from a wider growing area. This has the potential to introduce exotic pests and diseases to New Zealand. An analysis of the biosecurity risks has therefore been completed.

The analysis considers the biosecurity risks of importing into New Zealand for consumption, fresh fruit of three species of pear (*Pyrus bretschneideri*, *Pyrus pyrifolia* and *Pyrus* sp. nr. *communis*), from China. The commodity definition "*Pyrus* fresh fruit from China" includes fruit in their skins with a pedicel attached, and no leaves. The risk assessments for potential hazard organisms take as the base line that the pear production and export process (standard commercial practise) will be undertaken and managed as described by the General Administration for Quality Supervision and Inspection and Quarantine of the People's Republic of China. However, elements of the production and packing process that, that may be critical to risk mitigation are not assumed to occur and are considered separately as risk management options. Such elements include bagging of fruit in the orchard, airbrushing in the packhouse, refrigerated storage and phytosanitary inspection.

Of the more than 1000 organisms identified as being potentially associated with the commodity, 37 were assessed to be biosecurity hazards on the commodity. Risk management measures can be justified for these organisms and options for managing the risks associated with them are presented. These options will form the basis for a new import health standard for importing pears from China into New Zealand.

Table 1 provides possible risk management options for each identified hazard organism. Options for fruit of *Pyrus* sp. nr. *communis* are presented separately from those for *P. bretschneideri*, *P. pyrifolia* because they are primarily grown in a different part of China and bagging of *P.* sp. nr. *communis* fruit is not a viable option because it compromises fruit ripening.

Table 1. Summary of risk management options

Hazard organism: Scientific name and organism type (page number given in brackets)	Measures that could be considered options for the management of biosecurity risks: *P. pyrifolia* and *P. bretschneideri*	Measures that could be considered options for the management of biosecurity risks: *Pyrus* sp. nr. *communis* (from Xinjiang Province)
Fungi		
Alternaria gaisen (p31) *Alternaria yaliinficiens* (p32) *Alternaria ventricosa* (p31)	• Only resistant cultivars imported or • In-field surveillance or • Bagging and Visual inspection*	Not a hazard
Gymnosporangium fuscum (p37)	• Pest free area (some areas) or • In-field removal of alternative hosts or • Bagging and Visual inspection*	• Pest free area or • In-field removal of alternative hosts or • Visual inspection*
Venturia nashicola (p59)	• Pest free area or • Visual inspection*	• Pest free area or • Visual inspection*
Monilinia fructigena (p46)	• In-field surveillance or • Bagging and Visual inspection*	• Pest free area or • In-field Surveillance or • Visual inspection*
Phomopsis fukushii (p55)	• Pest free area or • Bagging of fruit and Visual inspection*	• Pest free area or • Visual inspection*
Insects		

Hazard organism: Scientific name and organism type (page number given in brackets)	Measures that could be considered options for the management of biosecurity risks: *P. pyrifolia* and *P. bretschneideri*	Measures that could be considered options for the management of biosecurity risks: *Pyrus* sp. nr. *communis* (from Xinjiang Province)
Bactrocera dorsalis (p82)	• Pest free area or • Cold treatment and Visual inspection*	• Pest free area or • Cold treatment and Visual inspection*
Harmonia axyridis (p69) *Chrysomphalus dictyospermi* (p111) *Lopholeucaspis japonica* (p142)	• Air brushing and Bagging and Visual inspection*	• Pest free area status or • Air brushing and Visual inspection*
Lepidosaphes malicola (p133)	• Pest free area status (some pears only) or • Bagging and Visual inspection*	• Visual inspection*
Parlatoria oleae (p153) *Cacopsylla chinensis (p105)* *Cacopsylla pyricola (p105)*	• Air brushing and • Bagging and Visual inspection*	• Air brushing and • Visual inspection*
Lepidosaphes conchiformes (p128) *Lepidosaphes pyrorum* (p138) *Leucoptera malifoliella* (p247) *Dolycoris baccarum* (p118) *Pempelia heringii* (p267) *Spilonota albicana* (p273) *Spilonota ocellana* (p273)	• Bagging and Visual inspection*	• Visual inspection*
Acrobasis pirivorella (p202) *Adoxophyes orana* (p207) *Carposina sasakii* (p218) *Conogethes punctiferalis* (p226) *Cydia inopinata* (p234) *Pandemis heparana* (p261)	• In-field control & Surveillance and Bagging and Visual inspection*	• Pest free area status or • In-field control & Surveillance and Visual inspection*
Aphanostigma iaksuiense (p97) *Pseudococcus comstocki* (p171) *Planococcus kraunhiae* (p165)	• Visual inspection*	• Pest free area status or • Visual inspection*

Hazard organism: Scientific name and organism type (page number given in brackets)	Measures that could be considered options for the management of biosecurity risks: *P. pyrifolia* and *P. bretschneideri*	Measures that could be considered options for the management of biosecurity risks: *Pyrus* sp. nr. *communis* (from Xinjiang Province)
Euzophera pyriella (p241) *Pseudococcus maritimus* (p177)	• Pest free area status (some pears only) or • Bagging and Visual inspection*	• Visual inspection*
Mites		
Amphitetranychus viennensis (p304) *Tetranychus kanzawai* (p310) *Tetranychus truncatus* (p316)	• Air brushing and Visual inspection*	• Air brushing and Visual inspection*
Tarsonemus yali (p302)	• Supply chain hygiene	• Supply chain hygiene

* visual inspection means formal phytosanitary inspection by AQSIQ officers prior to export

1 Risk analysis background and process

1.1 Background

There is an existing Import Health Standard (IHS) for Ya pears (*Pyrus bretschneideri*), from the People's Republic of China to New Zealand (MAFBNZ, 2007). China has requested access to the New Zealand market for a wider range of pear species from wider production areas. This has the potential to introduce exotic pests and diseases to New Zealand. An analysis of the biosecurity risks is therefore required.

1.2 Scope of the risk analysis

This document presents an analysis of the biosecurity risks of importing into New Zealand for consumption, fresh fruit of three species of pear (*Pyrus bretschneideri*, *P. pyrifolia* and *Pyrus* sp. nr. *communis*), from China and identifies options for measures to manage to varying levels the identified risks. The identified options for measures will form the basis of a new import health standard for importing pears from China into New Zealand.

For the purposes of this analysis, the commodity definition "*Pyrus* fresh fruit from China" includes fruit in their skins with a pedicel attached, and no leaves.

1.3 Risk analysis process

The following briefly describes the Biosecurity New Zealand process and methodology for undertaking import risk analyses. For a more detailed description please refer to the Biosecurity New Zealand Risk Analysis Procedures (MAF, 2006). Figure 1 presents a flow diagram of the risk analysis process.

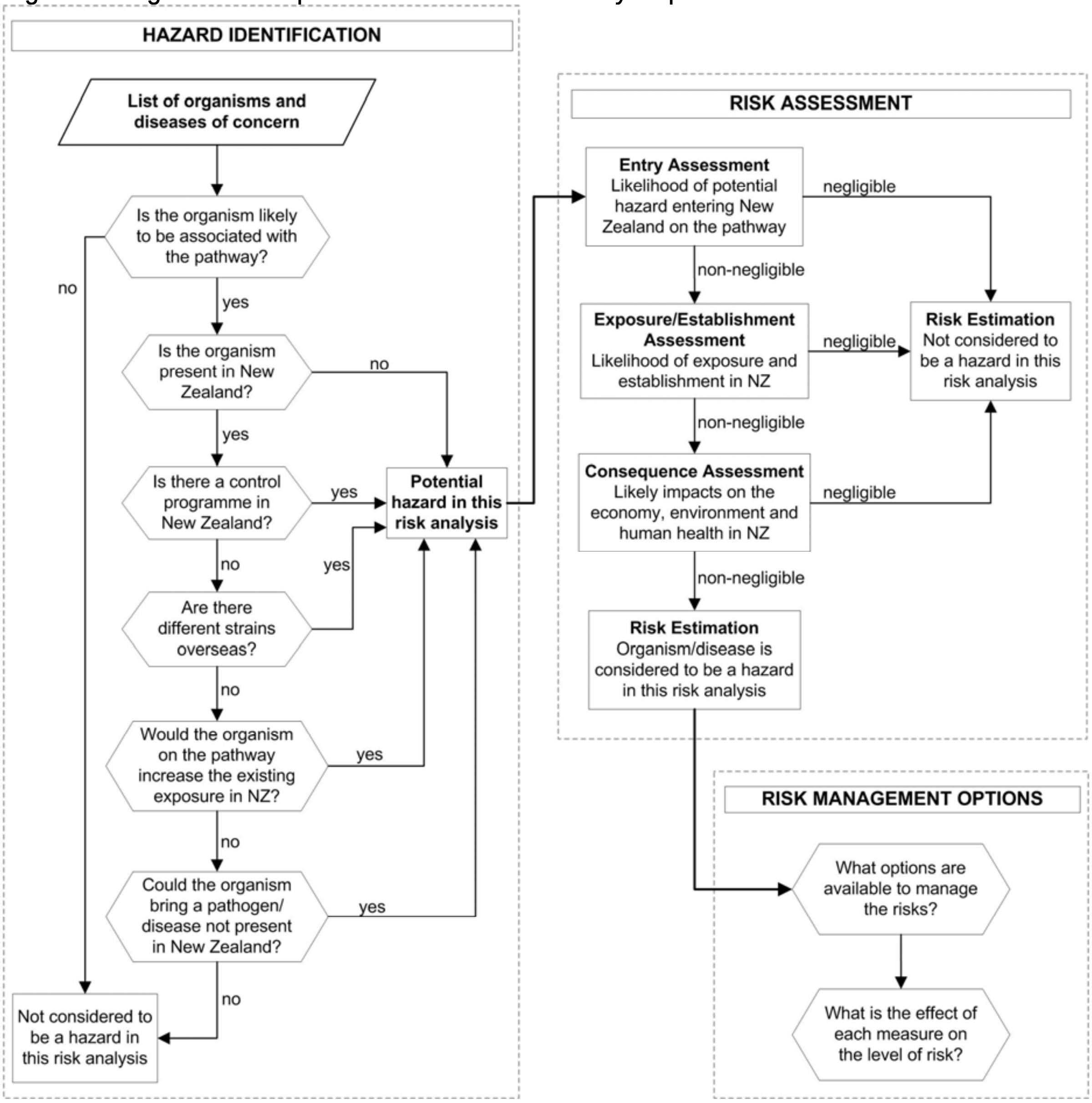
1.3.1 Commodity and pathway description

The first step in the risk analysis process is to describe the commodity and entry pathway of the commodity. This includes relevant information on:

- the country of origin, including characteristics like climate, relevant agricultural practices, phytosanitary system;
- pre-export processing and transport systems;
- export and transit conditions, including packaging, mode and method of shipping;
- nature and method of transport and storage on arrival in New Zealand;
- characteristics of New Zealand's climate, and relevant agricultural practices.

This information provides context for the assessment of potential hazard organisms.

Figure 1. Diagrammatic representation of the risk analysis process



The process outlined in Figure 1 is further supported by:

1.3.2 Assessment of uncertainties

The uncertainties and assumptions identified during the preceding hazard identification and risk assessment stages are summarised. An analysis of these uncertainties and assumptions can then be completed to identify which are critical to the outcomes of the risk analysis. Critical uncertainties or assumptions can then be considered for further research with the aim of reducing the uncertainty or removing the assumption. The risk assessment may need to be reviewed if information becomes available which would change these assumptions.

Where there is significant uncertainty in the estimated risk, a precautionary approach to managing risk may be adopted. In these circumstances risk management measures should be reviewed as soon as additional information becomes available[1] and be consistent with other measures where equivalent uncertainties exist.

1.3.3 Management options

For each organism classified as a hazard, a risk management step is carried out, which identifies the options available for managing the risk. Recommendations for the appropriate phytosanitary measures to achieve the effective management of risks are not made in this document. These will be determined when an Import Health Standard (IHS) is drafted.

As obliged under Article 3.1 of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement), the measures adopted in IHSs will be based on international standards, guidelines and recommendations where they exist, except as otherwise provided for under Article 3.3 (where measures providing a higher level of protection than international standards can be applied if there is scientific justification, or if there is a level of protection that the member country considers is more appropriate following a risk assessment).

1.3.4 Review and consultation

Peer review is a fundamental component of a risk analysis to ensure the analysis is based on the most up to date and credible information available. Each analysis must be submitted to a peer review process involving recognised and relevant experts from New Zealand or overseas. The critique provided by the reviewers is reviewed and where appropriate, incorporated into the analysis. If suggestions arising from the critique are not adopted the rationale must be fully explained and documented.

Once a draft risk analysis has been peer reviewed and the critiques addressed it is then published and released for public consultation. The period for public consultation is usually 6 weeks from the date of publication of the risk analysis.

All submissions received from stakeholders will be analysed and compiled into a review of submissions. Either a document will be developed containing the results of the review or proposed modifications to the risk analysis or the risk analysis itself will be edited to comply with the proposed modifications.

References for Chapter 1

MAF (2006) Biosecurity New Zealand risk analysis procedures. Ministry of Agriculture and Forestry, New Zealand, 201 pp. Available online at http://www.biosecurity.govt.nz/files/pests-diseases/surveillance-review/risk-analysis-procedures.pdf

MAFBNZ (2007) Import health standard commodity sub-class: fresh fruit/vegetables: Pyrus bretschneideri from the People’s Republic of China (Hebei and Shandong Provinces) (1st September). Ministry of Agriculture Biosecurity New Zealand. 19pp. Available online at: http://www.biosecurity.govt.nz/imports/plants/index.htm

[1] Article 5.7 of the SPS Agreement states that “a Member may provisionally adopt sanitary …. measures” and that “Members shall seek to obtain additional information …. within a reasonable period of time.” Since the plural noun “Members” is used in reference to seeking additional information a co-operative arrangement is implied between the importing and exporting country. That is, the onus is not just on the importing country to seek additional information.

2 Commodity and pathway description

This chapter provides information that is relevant to the analysis of biosecurity risks and common to all organisms or diseases potentially associated with the commodity and pathway. It also provides information on New Zealand's climate and geography to lend context for assessing the likelihood of establishment and spread of potential hazard organisms.

2.1 Commodity description

2.1.1 Commodity definition

In this risk analysis the commodity, "*Pyrus fresh fruit from China*" is defined as fresh fruit from three species of pear (*Pyrus bretschneideri*, *Pyrus pyrifolia*, and *Pyrus* sp. nr. Communis) and includes fruit in their skins with a pedicel attached, and no leaves.

2.1.2 Taxonomy and genus description

The genus *Pyrus* (pear) is a member of the Family Rosaceae, sub-family Pomoideae (Maloideae), which also includes other common edible pome species, such as *Malus* (apple) (Jackson, 2003). The genus includes species and cultivars of great diversity (Ghosh et al, 2006). These species are generally capable of natural hybridisation and the demarcation of species by classical methods has been imprecise.

The native range of the genus spans from south-western Europe eastward through Asia, and southward through North Africa and the Middle East (CPC, 2007). The primary centre of origin of *Pyrus* is within the region that includes Asia Minor, the Caucasus, Soviet Central Asia and Himalayan India and Pakistan, possibly even as far as western China (Watkins, 1976).

There are over thirty species of *Pyrus*; the most common are the European-native *Pyrus communis*, and the Asian (nashi) pear, *Pyrus pyrifolia*, which is native to the Orient (Jackson, 2003). Two clear groups of *Pyrus* species exist: the western (European or Occidental) pears and the eastern (Asian) pears. The main centre of diversity of the western group lies in the Caucasus (a geopolitical region located between Europe, Asia and the Middle East), where whole forests occur (Rubtsov, 1931). The main species, *Pyrus communis* (European pear), is thought to be derived from wild relatives native to the Caucasus Mountain region and Eastern Europe (Volk et al, 2006).

The commercial pear cultivars native to East Asia are composed of five groups: Ussurian pear, Chinese white pear, Chinese sand pear, Xinjiang pear, and Japanese pear. Ussurian pear cultivars are derived from *Pyrus ussuriensis* and Chinese sand pear cultivars from *P. pyrifolia* grown wild in central and southern China. However, the origin of Chinese white pear cultivars (*Pyrus bretschneideri*) and the genetic makeup of Xinjiang pears (*Pyrus* sp. nr *communis*) are more obscure (Teng and Tanabe, 2004).

Pear flowers have five petals and sepals, numerous stamens and a single pistil (Jackson, 2003). They are white in colour and are borne in umbels, and the leaves are oval and simple (Jackson, 2003). In the southern provinces of China, it is common to find repeated blooming and fruiting in one season, which can lead to fruit set for up to four times in the same year in some cultivars (Jones and Aldwinckle, 1990; Shen, 1980).

The cores of pear fruit comprise five capsules, in a fleshy endocarp which is surrounded by skin tissue. The skin texture is fine and skin colour can vary from green to yellow to red (Jackson, 2003). The flesh is far juicier than that of an apple (Jackson, 2003) and the shape varies from apple-shaped *(P. pyrifolia)* to teardrop-shaped *(P. bretschneideri* and *P. communis)*. The flesh of pears, like other pome fruit, is usually sweet and soft. The flesh contains gritty cells called stone cells and the flavour of the flesh differs with each variety (Jones and Aldwinckle, 1990). In European pears, fruit is borne on spurs, whereas some Chinese pears can bear fruit laterally on the previous year's growth (Shen, 1980).

Pears are cultivated in cool, temperate and humid conditions throughout the world for their fruit, or occasionally as ornamental trees. European pear trees can attain heights of up to nine metres, with trunks more than thirty centimetres in diameter. In order to prevent over-vigorous and large tree growth, European pear cultivars are usually grown on rootstocks belonging to *Cydonia oblonga* (quince) or *P. pyrifolia* (Jackson, 2003; Wood, 1997). Pear trees in China can attain heights of up to 30 metres with trunk circumferences of three to four metres and branch spreads of up to 25 metres. They have been cultivated for the last 3000 years and it is not uncommon to find trees that are 300 years old and still producing heavy crops (Shen, 1980).

The pear is a climacteric fruit; it does not fully ripen on the tree and instead ripens in storage, the exception being *Pyrus pyrifolia*, which is sometimes harvested when ripe. Once pears are stored at temperatures of -1 to 1°C, ethylene production is stimulated, and as a consequence, the pear fruit ripens (Chen, 2000).

2.1.3 Species description – *Pyrus bretschneideri* Rehder

Synonymy: *Pyrus ×bretschneideri* Rehder
Common names: Ya pear, duck pear, Chinese white pear, snow pear, bai li

P. bretschneideri is native to northern China and occurs only in China. It is known to grow wild mostly in the provinces of Hebei and Shanxi (Shen, 1980). Currently, it is cultivated in Hebei, Shandong, Liaoning, Shaanxi, Guangdong, and Jiangxi. It makes up over 60% of pear production in China (Saito et al, 2005).

Chinese taxonomists have assigned cultivars of Chinese white pears to *P. bretschneideri*, although there has been speculation that *P. bretschneideri* might be a natural hybrid between *P. betulifolia* and cultivated *P. pyrifolia*, and that they may originate from hybridisation between *P. ussuriensis* and *P. pyrifolia* (Teng and Tanabe, 2004). Several molecular methods have been used to test this. Using RAPD (Random amplification of polymorphic DNA) analysis, Teng and Tanabe (2004) found no relationship between Chinese white pears and *P. betulifolia* or *P. ussuriensis*, but found that Chinese white pear cultivars (*P. bretschneideri*) are most closely related to Chinese sand pears (*P. pyrifolia*). Using AFLP (Amplified fragment length polymorphism) analysis, Bao and others (2008) also found that Chinese white pears (*P. bretschneideri*) and Chinese sand pears (*P. pyrifolia*) were closely related.

P. bretschneideri is a deciduous tree growing up to six metres. In China, it flowers in May and the fruit ripen from September to October. To provide quality fruit, *P. bretschneideri* prefers a good well-drained loam soil in full sun but also grows well in heavy clay soils. Established plants of *P. bretschneideri* are drought tolerant and certain cultivars can withstand temperatures of -25°C. The shape of the fruit varies from pyriform to obovate and fruit are medium to large. The pedicel is long and the calyx deciduous. The flesh is fragrant and the fruit is crisp, juicy and sweet and it contains few stone cells (Shen, 1980).

Fruit is harvested in late September (Ju, 1991), prior to ripening. When refrigerated at 0°C, the pears can have a storage life of up to six months (Shen, 1980).

2.1.4 Species description – *Pyrus pyrifolia* (Burm. f.) Nakai

Synonymy: *Ficus pyrifolia* Burm. f.
Pyrus serotina Rehder
Common names: nashi pear, sand pear, Asian pear, apple pear, golden pear

P. pyrifolia grows wild in the Yangtze River Valley (Shen, 1980). It is currently grown in Gansu, Liaoning and Shanxi provinces. Unlike *P. bretschneideri*, it is cultivated in other parts of the world, including New Zealand (McArtney and Wells, 1995).

In the northern hemisphere, *P. pyrifolia* is a deciduous tree growing to ten metres (Shen, 1980) and flowering in April. It is hardy but less frost resistant than *P. bretschneideri*. It prefers well-drained loamy or heavy clay soils. The tree can tolerate light shade but fruits very well with maximum light. It can tolerate excessive moisture and a range of soil types if they are moderately fertile and established plants are drought-tolerant (White et al, 1990). The fruit's flesh is white, crisp and extremely juicy, and it has many stone cells (Shen, 1980). The flavour is a mixture of sweet and sour and it has a refreshing, light taste (Yue et al, 2005). The fruit has an irregular, obovate shape and the skin is thin and green-yellow with red russet. The calyx is usually deciduous and the pedicels very long (Shen, 1980). The size of the fruit varies from very small to very large (Shen, 1980).

In the northern hemisphere, *P. pyrifolia* is harvested between late September and late December (Tianfeng, 2008). Nashi pear can be picked prior to ripening or when completely ripe on the tree (Jones and Aldwinckle, 1990). *P. pyrifolia* is refrigerated at 0°C after picking (MAFBNZ, 2008) and must be stored at more than 90% relative humidity to prevent water loss and avoid compromising the texture of the skin and flesh (White et al, 1990). The storage life can be up to 20 weeks if fruit is harvested at optimum maturity (White et al, 1990).

2.1.5 Species description – *Pyrus* sp. nr. *communis*

Synonymy: *Pyrus sinkiangensis* Yu
Common names: fragrant pear, Koerle pear, Xiangli pear, Xinjiang pear

P. sp. nr. *communis* is mainly distributed in north-western China, and suspected to be of hybrid origin; previous studies have indicated that the popular local Chinese cultivar Korla's Xiangli originated as a hybrid between *Pyrus communis* and *P. bretschneideri* (Zhang and Wang, 1993). AFLP analysis of Xinjiang pear cultivars (*P.* sp. nr. *communis*) has also indicated a close relationship with European pear (*P. communis*) cultivars (Pan et al, 2002). However, RAPD analysis has indicated that at least *P. communis*, *P. armeniacaefolia* and Chinese white pears or sand pears have been involved in the origin of Xinjiang pears (Teng and Tanabe, 2004).

P. sp. nr. *communis* can grow up to thirteen metres. It has similar preferences to the other pear species described and dislikes very acidic soils and exposed environments. *Pyrus* sp.

nr. *communis* has a distinctive sweet flavour and scent, and the flesh is soft and juicy. The skin of fragrant pear is "jade" green and its shape is also distinctive; it has a persistent calyx, and a short pedicel (Garland, 1995).

Harvest of *P*. sp. nr. *communis* occurs in late August to mid-September in Xinjiang, just prior to ripening (Li et al, 2007). Optimum storage conditions for *P*. sp. nr. *communis* are similar to those for European pears. It can last up to eight months in cold storage at 0°C (Tianfeng, 2008).

European pears (*Pyrus communis*) are harvested around mid to late summer, just before they are completely ripe. If immature fruit is harvested, they can be susceptible to physiological disorders such as superficial scald (browning of the skin), shrivelling and friction discolouration. Similarly, core breakdown and carbon dioxide injury can occur when over-ripe fruit is harvested (Chen, 2000). Once harvested, they usually ripen within one to two weeks; to avoid spoilage and allow for longer storage life, pears are refrigerated straight after harvest. If they are harvested when fully ripe, the taste and texture is compromised and fruit is more susceptible to decay.

2.2 *Pathway description*

2.2.1 Commodity production

The fruit from pear trees is ranked as the third most important fruit crop in the world, in terms of exports (Chen, 2000). World pear trade is dominated by Argentina and China on the export side and Russia and the EU on the import side. Argentina's exports contributed 23% of total global pear exports in 2006, valued at US$337 million. The leading species exported from Argentina is *Pyrus communis* (USDA, 2007). In the same year, China contributed 16% of total world pear exports (valued at US$148 million). In 2006, New Zealand's pear exports (*P. communis*) comprised 2.3% of world pear exports (Pipfruit NZ Inc., 2007; World Trade Atlas, 2007).

2.2.2 Pear production in China

In China, there are thirteen known indigenous species of *Pyrus*, each adapted to a range of environmental conditions. Pear is the most widely grown fruit in the country (Shen, 1980). In the last decade, there has been extensive planting and in 2002, the planted area was over one million hectares (Saito et al, 2005). *P. bretschneideri, P. pyrifolia* and *P*. sp. nr. *communis* are exported from China. Nearly 70% of China's pear production comprises late-maturing cultivars of *P. bretschneideri*, such as 'Dangshansu', 'Xuehua' and 'Ya' (Saito et al, 2005). The provinces Hebei and Shandong are the leading pear producing provinces in China, accounting for 30 to 40% of pear production (Branson et al, 2004). Other provinces, including Shaanxi, Shanxi, Gansu, Liaoning, Jilin, Henan and Anhui provinces, are also commercial producers of *P. bretschneideri* and *P. pyrifolia*. The main production area for *P*. sp. nr. *communis* is Xinjiang Autonomous Region (Figure 3).

At present, China exports 10% of its pear produce. This figure is expected to rise because:

i) China's export pear prices are lower than other countries (USDA, 2006).
ii) Improvement of fruit quality and the implementation of pest programmes in China (USDA, 2006).
iii) Increasing numbers of plantings, leading to increased pear production and percentage of produce destined for exports.

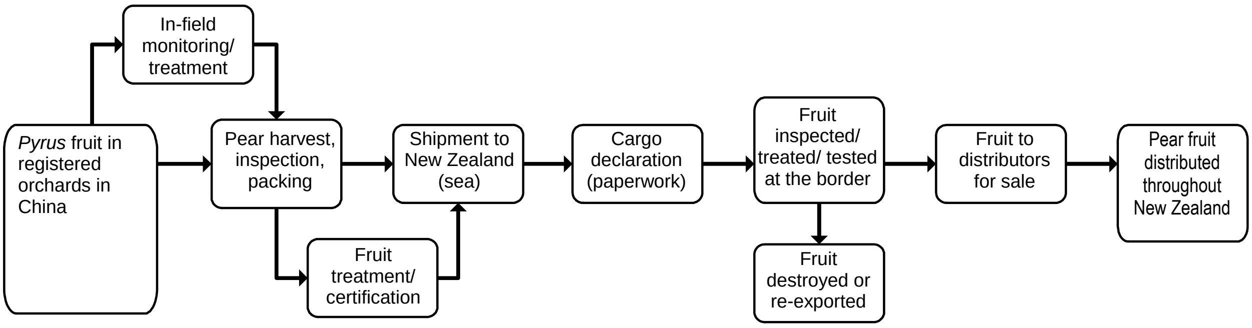
The increase is forecast to offset other big exporters, such as Argentina, and China is predicted to become the global export leader for pears (USDA, 2006). Fresh consumption of pears in China accounts for more than 90% of national production, while the remainder is processed (USDA, 2006).

2.2.3 Import pathway

Under New Zealand's existing import requirements for *Pyrus bretschneideri*, the commodity is prepared for export such that organisms that are regulated by New Zealand and are present in China, are not present (MAFBNZ, 2007). Fruit is sea-freighted to New Zealand and kept in a refrigerated holding facility after arrival (Bob Clarke, 2008, Paragon Produce, pers. comm. 10 July 2008). The fruit is then distributed to supermarkets, fruit and vegetable markets and other shops for consumption. It is assumed that a similar process will apply to any new species imported.

Figure 2 illustrates the potential pathway of pear fruit from China to New Zealand.

Figure 2. Potential *Pyrus* fresh fruit pathway from China to New Zealand.



China's regulatory framework for pear exports

In China, pear production and processing for export is overseen by the Entry-Exit Inspection and Quarantine Bureau of the People's Republic of China (CIQ). CIQ is the government compliance organisation working to regulations enacted by the General Administration for Quality Supervision and Inspection and Quarantine of the People's Republic of China (AQSIQ). The system includes a number of measures to reduce the risk of potentially hazardous organisms being associated with the commodity at the time of picking, packing and storage and entry of potentially hazardous organisms into New Zealand.

AQSIQ (2007) has provided technical information on the pear production and export process. Additional information on the growing, harvesting and packing processes of P. *bretschneideri* and *P. pyrifolia* in Hebei and Shandong provinces, is provided in a report of a field trip to China by MAFBNZ staff (MAFBNZ, 2008) .

Pre-harvest operations

Pear orchards in China that are permitted to export *Pyrus* are registered with AQSIQ. Registration is based on an audit of the sites and activity records maintained during the previous season Requirements for registered orchards include:

- A mixture of programmed pesticide application (at least at bud break, flowering and fruit set) and spraying when pests and diseases become apparent. All applications of pesticides must to be recorded in a spray diary ,including application rates (MAFBNZ, 2008). Staff members involved in pesticide application undergo annual training and must have an agricultural background and qualification (MAFBNZ, 2008). Low toxic and low residue pesticides are to be used in the orchard (AQSIQ, 2007).

- Field hygiene: ensuring that a clean environment is kept in the orchard (AQSIQ, 2007).
- Pest monitoring and control: registered orchards are required to set up an effective pest and disease control plan (AQSIQ, 2007). Orchards are inspected at least weekly by orchard staff for pests and diseases. Any incidents are reported to CIQ staff (MAFBNZ, 2008).
- A fruit fly monitoring programme using traps for med fly, oriental fruit fly and a general fruit fly lure is undertaken over the growing season (MAFBNZ, 2008).
- Fruit are thinned to one fruit per spur within the first two weeks of fruit set and the remaining pear is bagged not more than one month after petal fall and before the fruit is 2.5 cm in diameter, mainly to prevent infestation from insects (AQSIQ, 2007). *Pyrus.* sp. nr. *communis* fruit are not bagged (AQSIQ, 2007). Small bags are used initially on young fruit of *P. pyrifolia* to limit wind resistance, and larger bags are used later in the season (MAFBNZ, 2008).
- Visual inspection of pears in the orchard throughout fruit growth and development. Fruit are sampled with the bags attached, and if they are infested, the tree is sprayed and the fruit removed in orchards containing *Pyrus bretschneideri,* and the whole orchard is sprayed in the case of *P. pyrifolia*. Staff members involved in inspection undergo annual training and must have an agricultural background and qualification (MAFBNZ, 2008).

Harvest and post-harvest management:

- Fruit are harvested with the bags on, in the case of *P. bretschneideri* and *P. pyrifolia*, and transported in secured containers to the processing facilities. The orchard block, pickers, date of harvest and the weight of harvest are recorded (MAFBNZ, 2008).
- Pack-houses for export pears must be registered with AQSIQ. Registration requires a complete quality administration system including pest monitoring and control (AQSIQ 2007).
- On arrival at the processing facility the orchard records are reconciled with the cargo (MAFBNZ, 2008).
- Fruit is debagged either outside or in a separate area of the processing facility and graded to removed any damaged or diseased fruit . Fruit not of export quality is diverted to the domestic market. Diseased or infested fruit is reported to be destroyed by deep burial 2km away from any registered orchard or processing facility (MAFBNZ, 2008).
- Qualifying fruit is moved into the processing area through an entrance shielded to prevent entry of pests (MAFBNZ, 2008).
- Fruit processing involves grading by one person, air brushing with high-pressure air guns to remove contaminants by a second person and a final grading and addition of a sticker by a third person (MAFBNZ, 2008).
- Contaminants airbrushed from the pears may or may not be collected for identification of pests. Samples of up to 10% of fruit are inspected by experienced and trained company staff for pests and diseases using a magnifying glass. Depending on the organisms detected affected pears may be regraded and air

brushed once more or the whole lot (from one orchard block) may be rejected for export (MAFBNZ, 2008).

- The fruit is stored between 0°C and 1ºC (AQSIQ, 2007) until, and during, export to maintain fruit quality, with controlled atmospheres if required (MAFBNZ, 2008).

- Finally, the Entry-Exit Inspection and Quarantine Bureau of People's Republic of China (CIQ) is required to inspect the containers destined for export (MAFBNZ, 2008). CIQ inspections involve the use of magnifying glasses and dissecting microscopes. CIQ check records from the facility/orchard and, if they are approved, the containers are sealed (AQSIQ, 2007; MAFBNZ, 2008). A phytosanitary certificate is issued once fruit are approved (AQSIQ, 2007).

- At the end of each season, each orchard and processing facility is audited by CIQ (under AQSIQ standards) to ensure the sites are compliant with registration requirement (MAFBNZ, 2008).

For the purposes of assessing likelihood of entry of organisms in this risk analysis, it is assumed that the pear production and export process will be undertaken as described. However, elements such as bagging, airbrushing, and refrigerated storage, that may be critical in risk mitigation are not assumed to occur and will be considered separately as risk management options.

Distribution and use within New Zealand

Pears imported from China are likely to arrive in New Zealand between October and January. From the border, fruit would be transported to the main city centres in New Zealand, either to wholesalers or retailers, and from there to the food service industry or to individual consumers. Retailers are more likely to be located in urban areas than wholesalers. Waste is potentially generated at any of these points, with wholesalers and retailers potentially disposing of unmarketable fruit, and consumers disposing of waste or uneaten fruit. Because pear fruit skin is often eaten, limited amounts of waste material would be generated from good quality consumed fruit, apart from the core. Fruit that is culled or unsold by wholesalers and retailers is likely to be to be put into a rubbish bin or skip (closed or open) and be taken to landfill. Some may be disposed to the field as stock feed but this is likely to be a small proportion. Waste disposed of by consumers is likely to be discarded in domestic or public rubbish bins, compost, rubbish dumps or randomly onto the roadside or in reserves. In rural areas pear waste may be used as animal feed. Infested fruit/remains disposed of as bagged waste into landfill or into sewage via domestic waste disposal would have a negligible likelihood of exposure to suitable hosts in New Zealand. Infested fruit/remains disposed of into domestic compost, or randomly by the roadside would have a higher likelihood of exposure to a suitable host. There is very little information available regarding domestic and industry pathways and practices. A survey carried out in the United Kingdom showed that between 15 and 25% of households compost at home (Ventour, 2008), but data for New Zealand does not appear to be available.

2.3 *Exporting country climate*

China is a mountainous country, with two-thirds of its total land area covered by mountains, hills and plateaus. It covers a vast continental area of about 9.6 million km², from sub-arctic regions in the north-east and north-west (in Heilongjiang and Xinjiang), to subtropical and tropical regions such as Guangdong, Guangxi and Hainan Island in the south. The main pear growing regions are the temperate areas shown in Figure 3.

Figure 3. Map of China showing the main pear growing areas in green.

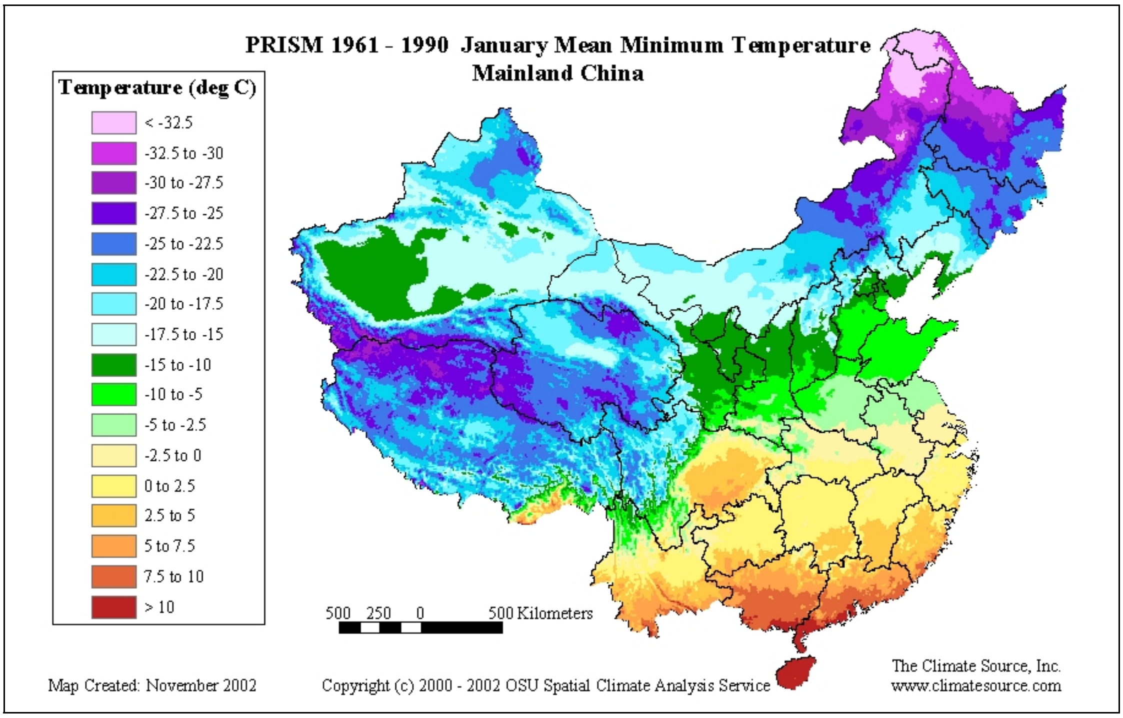
Monsoon winds, caused by differences in the heat-absorbing capacity of the continent and the ocean, dominate the climate. Alternating seasonal air-mass movements and accompanying winds are moist in summer and dry in winter. The advance and retreat of the monsoons account in large degree for the timing of the rainy season and the amount of rainfall throughout the country. Tremendous differences in latitude, longitude, and altitude give rise to sharp variations in precipitation and temperature within China. Although most of the country lies in the temperate belt, its climatic patterns are complex (Photius, 2004).

There is a natural geographic and climatic line which divides China between temperate and subtropical environments. Shaanxi has a continental monsoonal climate, with great difference between the areas north and south of the Qinling range (Peoples Daily, 2008). The range constitutes a natural border between north and south China, featuring dry temperate climate in the north and humid subtropical climate in the south.

Mean minimum temperature data for January over a 30 year period (1961–1990) in China (Figure 4) show that all pear growing provinces have winter temperatures which drop below 0ºC for at least two months of the year.

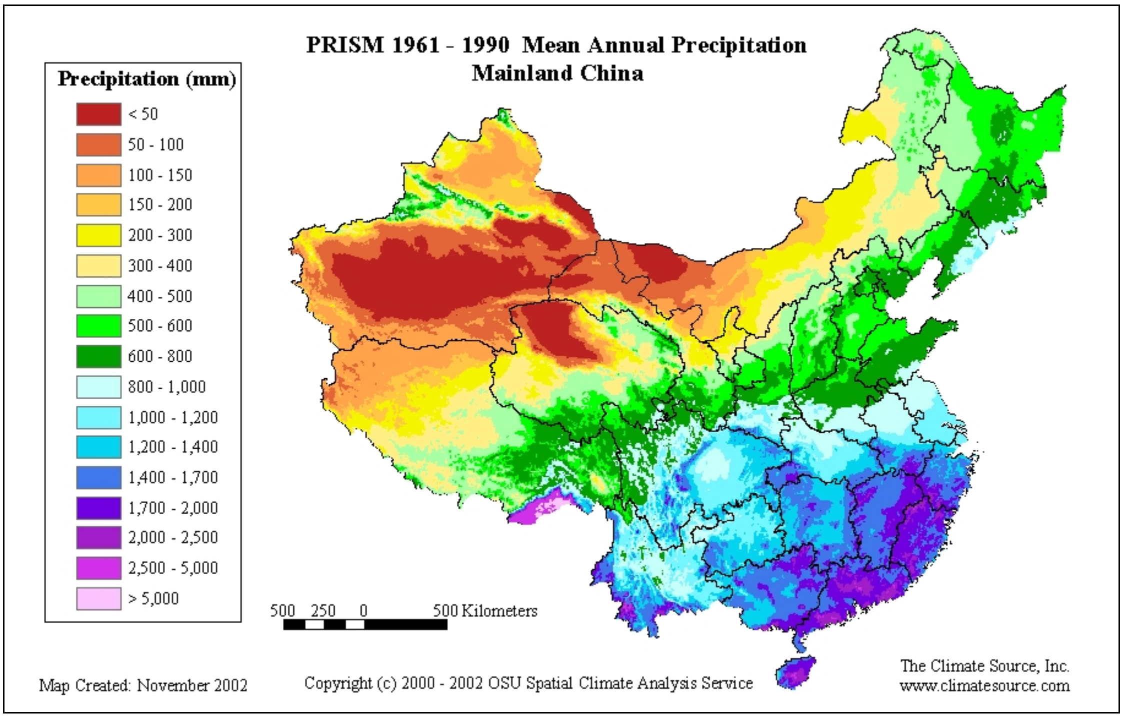
Temperatures in pear producing regions of China are either mid-temperate, such as northern Xinjiang, warm-temperate, such as Shandong, Shanxi, Shaanxi and Hebei Provinces, or tropical, such as Yunnan province. Precipitation (Figure 5) is quite regular from year to year and the rainy seasons arrive in May and depart after September. The monsoons strike the south-east coast of China in April-May, then reach southern China in June, and in July-August they move up to northern China. Gradually, in October, the summer monsoons retreat from China. (www.asianinfo.org/asianinfo/china/geography.htm, www.travelchinaguide.com/intro/climate.htm).

Figure 4. Climate zones in China – mean January (winter) minimum temperatures.



From www.climatesource.com 2008.

Figure 5. Climate zones in China – annual precipitation.



From www.climatesource.com 2008.

2.4 *The New Zealand pear industry*

2.4.1 Pear production

Pears have been cultivated for consumption in New Zealand since the early twentieth century. They are grown in various regions with Nelson (South Island) currently the leading region, followed by Hawkes Bay (North Island). Several varieties of *P. communis* were planted in the first experimental pear orchard at Weraro (Manawatu Region, North Island) in 1903 (Wood, 1997).

Old varieties of *P. communis*, such as Beurre Bosc and Doyenne du Commice, are as popular as new types of Doyenne, such as Packham's Triumph and Taylor's Gold. Nashi pear (*Pyrus pyrifolia)* has been cultivated in New Zealand since the 1980s. At first, it was grown as a small part of existing orchards, consisting primarily of apples, European pears or kiwifruit (Wood, 1997).

Production of pears in New Zealand is slowly declining due to poor grower returns compared to other crops (such as apples) during the orchard establishment phase (Brewer and Hilton, 2005). Prior to 2002, a national total of 965 ha of *P. communis* cultivars was planted and this had decreased to 722 ha in 2006 (Pipfruit NZ Inc., 2008) and 412 ha in 2008 (Pipfruit NZ Inc., 2008). In addition, there was a 35% decrease in the planting area of *P. pyrifolia* from 1999 to 2003, reducing Nashi pears to 'boutique' fruit status (Brewer and Hilton, 2005). In 2002, 119 ha were grown (Statistics New Zealand, 2002). *P. pyrifolia* is generally grown in small areas widely spread through Northland, North Auckland, Gisborne, Hawkes Bay, Taranaki and Canterbury. The main growing areas are Waikato, Nelson and Bay of Plenty (Ian Turk, Nashi Growers Association NZ, pers. comm. 20 July 2008).

Prior to 1977 there were few named cultivars of *P. pyrifolia* in New Zealand, and these only in home gardens – most were the cultivar 'Nijisseiki'. In the mid-1970s, the Department of Scientific and Industrial Research (DSIR) introduced Japanese cultivars with the view to growing them for fresh, local, and export sales (McArtney and Wells, 1995).

P. pyrifolia was established as a commercial crop in New Zealand in 1983 (Oh and Klinac, 2003). The main cultivars grown in New Zealand are 'Hosui', 'Kosui', 'Shinsui', 'Nijisseiki', and 'Shinseiki' which have markedly different growth habits and flowering characteristics (Klinac et al, 1995), 'Hosui' being the most commercially important (Oh and Klinac, 2003). Ian Turk (Nashi Growers Association NZ, pers. comm. 20 July 2008) notes that Hokuhu is also grown commercially. Crosses such as Dan Bae (*P. pyrifolia* × *P. ussuriensis*) are available, and new crosses are expected to be released in approximately two years. These crosses are expected to be grown on a larger scale than nashi, and to be an alternative to European pears (Michael Butcher, Pipfruit NZ Inc., pers. comm. 17 June 2008).

The New Zealand fresh pear industry is largely export focused. The processing industry is small and focuses on the domestic market (Brewer and Hilton, 2005). In 2006, a total of 4695 tonnes of pears (mainly *P. communis*) were produced for export. This was the lowest national export volume in nearly a decade reflecting decreased planted area as well as declining fruit yields. The return per tray carton equivalent (TCE) averaged $32.38, which was a 20% increase on the previous year ($26.03 per TCE), and most likely influenced by the strong New Zealand dollar against other world currencies (Pipfruit NZ Inc., 2008). In the 2008 season *Pyrus* earned $9.1million in export sales and $2.9million in domestic sales (M. Butcher Pipfruit NZ Inc. pers.comm. 26 September 2009).

Export of *P. pyrifolia* decreased by 70% between 1999 and 2003 as a result of poor grower returns and strong competition from other well-established orchard crops. In contrast, pear imports into New Zealand have grown by over 50% in recent years, with 70% of imports from Australia (Brewer and Hilton, 2005). Currently, *P. bretschneideri* is the only species of pear imported from China.

Pyrus crops (European and Nashi) in NZ are relatively free of disease. Few control strategies need to be employed by NZ pear orchardists to manage diseases (M. Butcher Pipfruit NZ Inc. pers.comm. 26 September 2009).

2.5 *New Zealand climate*

New Zealand's climate is complex and varies from warm subtropical in the far north to cool temperate climates in the far south, with severe alpine conditions in the mountainous areas. Mountain chains extending the length of New Zealand provide a barrier for the prevailing westerly winds, dividing the country into dramatically different climate regions. The West Coast of the South Island is the wettest area of New Zealand, whereas the area to the east of the mountains, just over 100 km away, is the driest (NIWA, 2007).

Most areas of New Zealand have between 600 and 1600 mm of rainfall, spread throughout the year with a dry period during the summer. Over the northern and central areas of New Zealand more rainfall falls in winter than in summer, whereas for much of the southern part of New Zealand, winter is the season of least rainfall (NIWA, 2007).

Mean annual temperatures range from 10°C in the south to 16°C in the north of New Zealand. The coldest month is usually July and the warmest month is usually January or February. In New Zealand generally there are relatively small variations between summer and winter temperatures, although inland and to the east of the ranges the variation is greater (up to 14°C). Temperatures also drop about 0.7°C for every 100 m increase in altitude (NIWA, 2007).

Sunshine hours are relatively high in areas that are sheltered from the west and most of New Zealand would have at least 2000 hours annually. The midday summer solar radiation index (UVI) is often very high in most places and can be extreme in northern New Zealand and in mountainous areas. Autumn and spring UVI values can be high in most areas (NIWA, 2007).

Most snow in New Zealand falls in the mountain areas. Snow rarely falls in the coastal areas of the North Island and west of the South Island, although the east and south of the South Island may experience some snow in winter. Frosts can occur anywhere in New Zealand and usually form on cold nights with clear skies and little wind (NIWA, 2007).

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3 Hazard identification

3.1 The hazard identification process

The first step is to identify organisms and diseases that could potentially be associated with fresh pears from China. The following sources were used:

- pest lists supplied by AQSIQ (AQSIQ, 2007)
- information derived from literature searches, including but not limited to: CAB abstracts (search: articles published between 1910 -2008), Pennycook (1989)
- database searches, including but not limited to: CPC (2007), Farr et al (2008), ScaleNet (2008),
- internet searches
- a review of organism interception records on previously imported pears (MAFBNZ, 2009).

Organisms on the list were screened and were classed as potential hazards if they were likely to be present on the importation pathway and were either not known to be present in New Zealand, or if they met any of the following criteria:

- present in New Zealand but vectors of pathogens or parasites that are not present in New Zealand
- known to have strains that do not occur in New Zealand
- of restricted geographically bounded distribution in New Zealand
- under official control in New Zealand
- differ genetically from those that occur in New Zealand in a way that may present a potential for greater consequences in New Zealand, either from the organism itself or through interactions with existing organisms in New Zealand
- the nature of the imports would significantly increase the existing hazard.

The results of this process are contained in Appendix 1. The list, although extensive, is not exhaustive. Whilst it includes most organisms likely to be carried on fresh pears from China, there may be information on additional organisms in sources that were not consulted, or which are not accessible. Organisms that were excluded from further consideration, although recorded as found on *Pyrus* fruit and not present in New Zealand, are discussed in Appendix 2. More than 1000 organisms were found to be associated with *Pyrus* spp. and of these, more than half were also recorded in China. Of the organisms recorded in China, 77 were considered to be potential hazards for the commodity and subjected to further assessment in Chapters 5–12.

3.2 Review of organism interception records

Records of organisms intercepted at the New Zealand border in association with imported Ya pears (*Pyrus bretschneideri*) from China, over the period 1999 to 2007 are summarised in Table 1.

Table 1: Interception records from imported Ya pears from China 1999–2007

Source: MAFBNZ, 2009

Scientific name	Taxonomy	Present in New Zealand	Lifestage	Viability	Number of records	Border/ post border
Alternaria alternata	Mitosporic fungi: Hyphomycetes	Yes	Unrecorded	Alive	1	Border
Alternaria sp.	Mitosporic fungi: Hyphomycetes	Unknown	Unrecorded	Unknown	4	Border; post border
Cryptophagus sp.	Insecta: Coleoptera: Cryptophagidae	Unknown	Unrecorded	Alive	1	Border
Cydia sp. nr. *molesta*	Insecta: Lepidoptera: Tortricidae	Yes	Larva	Alive	1	Border
Cydia molesta	Insecta: Lepidoptera: Tortricidae	Yes	Larva	Unrecorded	1	Post border
Cydia pomonella	Insecta: Lepidoptera: Tortricidae	Yes	Larva	Unrecorded	1	Post border
Penicillium sp.	Mitosporic fungi	Unknown	Unrecorded	Unknown	3	Border
Spilogona sp.	Insecta: Diptera: Muscidae	Unknown	Adult	Alive	1	Border
Identification not made to species	Insecta: Diptera: Drosophilidae	Unknown	Pupa; larvae	Alive	3	Border
Kleemannia sp.	Acarina: Ameroseiidae	No	Unrecorded		1	Post border
Proctolaelaps sp.	Acarina: Ascidae	Unknown	Unrecorded		1	Post border
Tarsonemus confusus	Acarina: Tarsonemidae	Yes	Adult, multiple females	Alive	3	Border
Tarsonemus yali	Acarina: Tarsonemidae	No	Adult, multiple females	Alive	6	Border
Tarsonemus sp.	Acarina: Tarsonemidae	Unknown	Adult, multiple females	Alive	12	Border
Tetranychus truncatus	Acarina: Tetranychidae	No	Adult	Alive	1	Border
Tydeus sp	Acarina: Tydeidae	Unknown	Unrecorded		1	Post border
Tyrophagus neiswanderi	Acarina: Acaridae	Yes	Adult male and female	Alive	1	Border
Tyrophagus putrescentiae	Acarina: Acaridae	Yes	Adult	Alive	4	Border
Tyrophagus sp.	Acarina: Acaridae	Unknown	Adult female	Alive	3	Border
Harmonia axyridis	Insecta: Coleoptera: Coccinellidae	No	Adult	Alive	1	Border
Pseudococcus calceolariae (P. comstocki?	Insecta: Hemiptera: Pseudococcidae	Yes	Adult	Alive	1	Border
Identification not made to species	Insecta: Hemiptera: Pseudococcidae	Unknown	Juvenile; egg	Alive	6	Border
Identification not made to species	Arachnida: Acari: Ameroseiidae	Unknown	Unrecorded	Alive	1	Border
Identification not made to species	Arachnida: Acari: Pyemotidae	Unknown	Adult	Alive	1	Border
Glycyphagus domesticus	Acarina: Glycyphagidae	Yes	Adult male; eggs	Alive	2	Border

New Zealand also imports pears from Australia, Korea and the USA. There have been numerous border interception records on pears from these countries, particularly Hemiptera and mites. These records can be helpful in demonstrating an association between a particular lifestage or particular group of organisms and exported pears, and will be discussed where appropriate in the risk assessments. Taken on their own, they do not demonstrate an association with this particular pathway.

The interceptions records are from the small samples taken from consignments of imported pears as they arrive in New Zealand. Any intercepted organisms are identified in Ministry of Agriculture and Forestry laboratories. The list is likely to contain only a small proportion of the organisms that have been associated with this trade, and organisms of larger size and contrast and with diagnostic keys readily available will be over-represented. The list is provided here to indicate the types of organisms that are known to be associated with pears in international trade.

Since not every organism on a pathway is detected, not every organism detected is recorded or identified, and search effort and the levels of identification done can vary, these data cannot be extrapolated to predict likely pest interception numbers for pears. They have only been used in this analysis for hazard identification and analysis of likelihood of entry. Viability data, where available, was used in assessing the efficacy of treatments.

Interception records are the best means of determining which hitchhiker organisms are likely to be associated with a commodity. These organisms have an opportunistic association with a commodity or item with which they have no biological host relationship. Nonetheless, they can be important hazards. Since the relationship is opportunistic, literature reviews and country of origin pest lists are not useful in identifying their relationship with the commodity.

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4 Overview of potential risk management options

4.1 Introduction

Risk management in the context of risk analysis is the process of identifying measures to effectively manage the risks posed by the hazard(s) associated with the commodity under consideration.

Since zero-risk is not a reasonable option, the guiding principle for risk management should be to manage risk to achieve the required level of protection that can be justified and is feasible within the limits of available options and resources. Risk management identifies ways to react to a risk, evaluating the efficacy of these actions, and presenting the most appropriate options.

This chapter provides general information about some options that may be available to manage any risks that are considered of sufficient concern to require mitigation. As the nature and strength of any measures will need to be commensurate with the type and level of the identified risks, actual mitigation options will be discussed within the risk management sections of each hazard risk analysis chapter.

Measures may be considered by themselves or in combination with other measures as part of a systems approach to mitigate risk.

Pears are produced commercially in China using pest management systems designed to reduce the likelihood of fruit being infested with hazard organisms and pathogenic agents before export (Section 2.2.3). It is assumed that all pears exported from China to New Zealand will follow these standards. They are not considered separately here. Only measures which have a specific, identifiable effect in mitigating risk from particular hazards are discussed.

4.2 Pest-free areas

The International Standards for Phytosanitary Measures Number 4: *Requirements for the establishment of pest free areas* (ISPM No. 4) describes the requirements for the establishment and use of PFAs as a risk management option for meeting phytosanitary requirements for the import of plants. The standard identifies three main components or stages that must be considered in the establishment and subsequent maintenance of a PFA:

- Systems to establish freedom (through surveillance/surveys);
- Phytosanitary measures to maintain freedom (through pest lists/import requirements/product movement restrictions); and
- Checks to verify freedom has been maintained (through inspection/notification of pest occurrence/monitoring surveys).

Normally PFA status is based on verification from specific surveys such as an official delimiting or detection survey. It is accepted internationally that organisms or diseases that have never been detected in, or that have been detected and eradicated from, an area should not be considered present in an area if there has been sufficient opportunity for them to have been detected.

When sufficient information is available to support a PFA declaration, this measure is usually considered to provide a very high level of protection.

4.3 *Pest free place of production (PFPP)*

The International Standards for Phytosanitary Measures Number 10: *Requirements for the establishment of pest free places of production and pest free production sites* (ISPM No. 10) describes the requirements for the establishment and use of pest free places of production as a risk management option for meeting phytosanitary requirements for the import of plants. A pest free place of production is defined in the standard as a "place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period". Pest freedom is established by surveys and/or growing season inspections and maintained as necessary by other systems to prevent the entry of the pest into the place of production.

When sufficient information is available to support a PFPP declaration, this measure is usually considered to provide a high level of protection depending on the epidemiological characteristics of the organism or disease in question. Surveillance for specific pests or diseases enables fruit from areas where presence has been detected to be excluded from the pathway.

4.4 *Bagging of fruit*

All pears to be exported (except *Pyrus* sp. nr. *communis*) are generally completely bagged to reduce the risk of exposure to pests and diseases. Bagging is likely to affect ripening of *Pyrus* sp. nr. *communis* pears because these require sun exposure during the ripening process. Small bags are used initially on young fruit of *P. pyrifolia* to limit wind resistance, and larger bags are used later in the season (MAFBNZ, 2008). All bags adopted are normally double-layered, light and rain proof paper bags. Bagging should occur within one month after petal fall and completed before the fruit grows greater than 2.5 cm in diameter (AQSIQ, 2007).

4.5 *Buffer zones around export orchards*

A buffer zone could be developed around export orchards in which no alternate hosts or non export pears are present. This could mitigate the risks associated with obligate alternate hosts of hazard organisms, such as rust fungi (*Gymnosporangium* spp.). This option would require an appropriate buffer zone to be a requirement for registration of export orchards.

4.6 *Airbrushing*

All pears to be exported are generally subject to airbrushing during the packing process. Whilst there is no information available on the efficacy of this measure in removing arthropods, it is expected that the process will dislodge some organisms from the external surface of fruit.

4.7 *Cold treatment*

The most frequently used temperature for quarantine treatment of fresh produce is 0–3°C (Mangan and Hallman, 1998), as a balance between maximising efficacy and minimising damage to the commodity. Sustained low temperature treatments have been shown to be effective, for example, on fruit flies for a wide range of fruit (De Lima et al, 2007; Heather et al, 1996; Paull, 1994).

Cold disinfestation has the advantage of being applied in several ways. The treatment can be carried out entirely in the exporting country, in transit, in the importing country, or through a combination of these options. *In transit* cold treatment can be applied during transportation in shipping containers, as well as in refrigerated trucks. Transit times between China and New Zealand are expected to be approximately three weeks.

4.8 *Irradiation*

Irradiation is an efficient, non-residue, broad spectrum disinfestation treatment recognised for its quarantine potential in fresh produce. It is a low dose application that is tolerated well by most fresh commodities. The major commercial uses of ionising radiation for fruit and vegetables include the inhibition of sprouting (potatoes and onions) and the extension of shelf-life in strawberries (Frazier et al, 2006).

Although irradiation can prolong the shelf life of foods where microbial spoilage is the limiting factor, fruit and vegetables generally do not retain satisfactory quality at the irradiation doses required (Lacroix and Vigneault, 2007). The firmness of certain pear varieties was affected by higher irradiation doses. However, for varying doses of irradiation under 1000 Gy, pears ripened normally after irradiation exposure and there was no increase in the incidence of disease (Drake et al, 1999).

If sterility is the specified outcome for irradiation, then live organisms would be expected to occur on treated produce. The ISPM No. 18 guidelines for irradiation use as a phytosanitary measure suggest it is preferable that pests are unable to emerge or escape the commodity unless they can be practically distinguished from non-irradiated pests (ISPM No. 18, 2003).

Food Standards Australia New Zealand (FSANZ) has approved and given food safety clearance to the use of irradiation as a phytosanitary treatment for a range of fresh fruit (NZFSA, 2009). Pears have not been assessed and approved. Irradiation has not been assessed as a risk management option for individual hazards in the following chapters, but it may be appropriate to consider its efficacy in the future.

4.9 *Methyl bromide fumigation*

Fumigation treats both internal and external infestations including those that are not visible through standard visual inspection. Factors affecting mortality include:

- Temperature; lower doses are generally required at higher temperatures due to the organisms' increased metabolic activity
- Life stage; the treatment regime must kill the most tolerant life stage that is associated with the commodity
- Resistance within populations

Methyl bromide is a widely used fumigant. The Montreal Protocol on Substances That Deplete the Ozone Layer is an international agreement designed to protect the stratospheric ozone layer. It stipulates that the production and consumption of compounds that deplete ozone in the stratosphere – chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform – are to be phased out by 2000 (2005 for methyl chloroform). Scientific theory and evidence suggest that, once emitted to the atmosphere, these compounds could significantly deplete the stratospheric ozone layer that shields the planet from damaging UV-B radiation. The use of methyl bromide as a quarantine treatment to eliminate quarantine pests has been exempt from the phase-out requirements, but as a signatory to the Protocol, New Zealand is committed to reducing its use.

Although, methyl bromide has been used widely for quarantine fumigations of fresh fruit, some fruits, or certain varieties, are susceptible to injury. The differences in varietal susceptibility are particularly noticeable in apples. Fruit may vary in susceptibility from one season to another; this is believed to be due to variations in the physiological condition of the fruit. Pears are considered generally tolerant but after fumigation fully ripe pears may break down more quickly than normal (Bond, 1984). The USDA fumigation manual indicates that methyl bromide fumigation may cause severe damage to Chinese, Japanese, Asian and Sand pears (TQAU USDA, 2008). For this reason methyl bromide fumigation has not been assessed as a risk mitigation option in the following chapters.

4.10 *Ethyl Formate*

Ethyl formate is a naturally occurring plant volatile with insecticidal properties. It has been widely used as a fumigant for stored product pests. Studies against pests of grapes that are of quarantine concern but rarely occur at levels requiring in-field treatment, such as thrips and spider mites, indicate that it has considerable potential. Tolerance to ethyl formate varies with the commodity, and efficacy depends on the organism and life stage (Simpson et al, 2007). Although little efficacy information on pears is available, fumigation with ethyl formate is considered for organisms for which few risk management options are available. However, care should be taken to ensure phytotoxicity levels are acceptable before applying any chemical treatments to plant material.

4.11 *Ozone*

Ozone can be generated by electrical discharges in air and has the advantage of not leaving chemical residues. The major disadvantage of using ozone for disinfestation is its oxidising action on many materials (Leesch and Tebbets, 2008). Although it generally damages plant tissues at the levels required to kill insects, the damage it causes varies greatly by commodity and does not occur under all environmental circumstances (Hollingsworth and Armstrong, 2005). Its efficacy varies depending on the life stage and commodity treated. Evidence to date indicates limited ovicidal properties. It has been shown not to adversely affect grapes but the tolerance of pears is not known. Ozone does not penetrate wet commodities such as fruit very well. However, it appears to have potential for treating surface pests such as thrips and mealybugs, spiders and mites (Hollingsworth and Armstrong, 2005; Leesch and Tebbets, 2008). Generally, most horticultural commodities will not tolerate prolonged exposure to reduced oxygen or enhanced carbon dioxide levels. There may be scope for combining controlled atmosphere and ozone treatments for short periods (Hollingsworth and Armstrong, 2005). Although there appears to be considerable potential to use ozone to disinfest pears of at least some life stages of surface pests, in the absence of demonstrated efficacy and information on the effect of pears, it is not considered further in this analysis.

4.12 *Visual inspection*

Visual inspection can take place along the whole production and post-harvest pathway. In-field monitoring and selection by certain criteria at harvest are considered good orchard practice, and the grading process provides another opportunity for screening. These are considered part of the production process described in Section 2.2.3.

There are opportunities for formal phytosanitary inspection both pre-export and on arrival in New Zealand. The purpose of these inspections is to determine whether there are viable organisms associated with the commodity, to gauge the efficacy of any risk management measures that have been applied, and to provide an opportunity for additional remedial measures such as commodity treatment, re-shipment or destruction. The inspection sampling regime depends on the level of confidence required for the absence of a particular organism, the detectability of the organism and the homogeneity of distribution of the organism within the commodity consignment (ISPM No. 23, 2005). These factors will be considered in relation to individual hazard organisms in Chapters 5–12.

4.13 *Assumptions and uncertainties*

There is considerable uncertainty about the efficacy of risk management measures. There is a paucity of information on the efficacy of measures against specific hazards. The objective is to ensure relevant life stages receive a lethal treatment while the plant tissue is affected as little as possible (Mangan and Hallman, 1998). There is evidence that the response of some life stages, such as insect eggs, to physical treatments varies with age (Corcoran, 1993). For example, Johnson and Wofford (1991) found that age was a significant factor in the response of two pyralid moths to cold treatment. In the case of tephritid fruit flies, the cold-susceptibility of *Anastrepha suspensa* decreased with age (Benschoter and Witherell, 1984).

The risk analysis uses available information to assess risk from organisms associated with *Pyrus* fruit. Significant uncertainties and associated assumptions are identified in the risk assessment for each potential hazard. Review of interception records collected once trade has commenced is a good way to test these assumptions as well as the efficacy of risk management measures.

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5 *Risk assessment of potential hazard organisms: Fungi*

5.1 *Alternaria spp. – A. gaisen, A. ventricosa, A. yaliinficiens*

Scientific name: *Alternaria gaisen* Nagano, 1920 (mitosporic fungi: hyphomycetes)
Other relevant scientific names: *Alternaria bokurai* Miura, 1928; *Alternaria kikuchiana* S. Tanaka, 1933
Common name: black spot of Japanese pear, ring-spot disease of pear

Scientific name: *Alternaria ventricosa* R.G. Roberts, 2007 (mitosporic fungi: hyphomycetes)

Scientific name: *Alternaria yaliinficiens* R.G. Roberts, 2005 (mitosporic fungi: hyphomycetes)
Common name: chocolate spot of Ya Li pear

5.1.1 Hazard identification

New Zealand status

Alternaria gaisen, *A. ventricosa* and *A. yaliinficiens* are not known to be present in New Zealand. Not recorded in: Landcare NZFUNGI (2008), Pennycook (1989), PPIN (2008).

Biology

Alternaria gaisen
Alternaria gaisen affects both the fruit and leaves of *Pyrus pyrifolia*, causing small, circular, black leaf spots or cracked lesions in immature fruit (David, 2002). Early authors emphasised the presence of dark, concentric rings in enlarging fruit lesions (Simmons, 1993). The first signs of infection of the fruit are the appearance of small black flecks on young fruit. The flecks expand to become the characteristic black spots and ultimately the fruit begins to rot (CPC, 2007).

Conidial production is favoured by warm and moist conditions (David, 1964); the optimum conditions for infection of *P. pyrifolia* by *A. gaisen* are a relative humidity (RH) of ca. 90% or more, and temperatures between 24 and 30°C. The optimum temperature for mycelial growth of isolates from *P. pyrifolia* has been reported to be 23°C (CPC, 2007). The conidia are dispersed by wind (David, 2002), and the fungus is expected to survive on dead leaves fallen from infected trees through the winter (CPC, 2007).

A. gaisen produces a ‘host-specific toxin’ which only affects susceptible varieties and is the basis of its pathogenicity to *P. pyrifolia*. The toxin is released from the germinating conidia at the point of infection and, in susceptible cultivars, leads to successful penetration of the host tissues (CPC, 2007).

Research has indicated that varieties of *P. pyrifolia* are more susceptible than varieties of *P. communis*, *P. ussuriensis* or their hybrids (David, 1964). A record of *A. gaisen* on *P. communis* in Greece was a misidentification and has been attributed to *A. alternata* (CAB International, 2001).

A. ventricosa

The only record of *Alternaria ventricosa* is the type description (Roberts, 2007). The type culture was isolated from a pedicel (fruit stem) of a Ya Li pear (*Pyrus bretschneideri*) showing disease symptoms. The status of *A. ventricosa* as a pathogen of *Pyrus* was not confirmed in inoculation studies (Roberts, 2007). There are no data on the incidence in China and this species is known only from a single US market interception.

A. yaliinficiens

Alternaria yaliinficiens is a monophagous pest of *P. bretschneideri* fruit. Little information is available on this species, which was not identified until 2005. There are no data on the incidence of this species in China, but it is assumed to be high, by implication from Roberts (2005). In 2001, numerous *P. bretschneideri* fruit were intercepted at US ports with a disease apparently caused by a species of *Alternaria*. It was subsequently shown that the disease was likely caused by several species of *Alternaria*, one of which has now been described and named *Alternaria yaliinficiens* (Roberts, 2005).

Isolates obtained from Chinese Ya Li pear in 2001 exhibited a distinct sporulation that differed from the patterns typical of "group 1", *Alternaria gaisen*, *A. arborescens*, *A. alternata*, *A. tenuissima*, or *A. infectoria*, or of the groups that these taxa represent. The predominant sporulation pattern of these isolates was described as a seventh recognisable pattern (Roberts, 2005).

Roberts (2005) used PCR to distinguish the *P. bretschneideri* isolates, and concluded that the morphological, pathological and genetic characteristics of the intercepted isolates clearly differentiated them from other *Alternaria* species known to occur on pome fruit or other substrates. Additionally, the disease caused by these isolates did not resemble black spot of Japanese pear (caused by *A. gaisen*), and was distinctly different from any pear disease described in the United States or any available literature. One of the isolates was described as the type of the new species, *Alternaria yaliinficiens* (Roberts, 2005). Roberts (2005) is unclear on what proportion of the isolates were identifiable as *A. yaliinficiens*. Sun and Zhang (2008) have since confirmed the presence of *A. yaliinficiens* in Hebei, China as well as in Wenatchee, USA. They used a combination of sporulation patterns, conidial morphology and random amplified polymorphism DNA analysis. In contrast Yan *et al*. (2009) using the same techniques did not find *A. yaliinficiens* in their samples from Hebei and Shandong provinces.

Hosts

- *Alternaria gaisen*: monophagous. *P. pyrifolia* (David, 2002; Sheng et al, 2004; CPC, 2007); *P. bretschneideri* (Wang and Zhang, 2003; Tai, 1979); *P. ussuriensis* (Tai, 1979). *A. gaisen sensu stricto* has not been shown to affect European pear, *P. communis* or its hybrids (CPC, 2007). Wang and Zhang (2003) record *A. gaisen* on *P. communis* from the USA, however, CPC (2007) states that it is absent from the USA and that the record is invalid.

- *A. ventricosa*: *P. bretschneideri* (Farr et al, 2007; Roberts, 2007)

- *A. yaliinficiens*: monophagous. *P. bretschneideri* (Farr et al, 2007; Roberts, 2005)

Plant parts affected

- *Alternaria gaisen* – fruit, leaves of *Pyrus* (David, 2002)
- *A. ventricosa* – fruit stem of *Pyrus* (Roberts, 2007)
- *A. yaliinficiens* – fruit of *Pyrus* (Roberts, 2005)

There has also been a high incidence of unidentified *Alternaria* rots, including mixed infections by several *Alternaria* species, on exported *Pyrus* ×*bretschneideri* from China, particularly to the USA (Roberts, 2005).

Geographical distribution

- *Alternaria gaisen*: China (Farr et al, 2007; CAB International, 2001; Zhuang, 2005); Japan, Korea, Taiwan (David, 2002; Roberts, 2005).

It is widespread within China; reported from: Hebei, Henan, Hubei, Jiangsu, Jilin, Shandong Liaoning, Qinghai, Guangdong, Guangxi, Gansu, Ningxia, Xinjiang and Zhejiang (CPC, 2007; CAB International, 2001;Zhuang, 2005;Wang and Zhang, 2003; Tai, 1979). Sun & Zhang (2008) failed to find it in isolates collected from Hebei province.

- *A. ventricosa*: China, Hebei province (Roberts, 2007).
- *A. yaliinficiens*: China, Hebei province (Roberts, 2005).

Hazard identification conclusion

A. gaisen, *A. ventricosa*, *A. yaliinficiens* are all associated with *Pyrus* fruit or stems and are recorded in China. They are not known to be present in New Zealand and are considered potential hazards.

5.1.2 Risk assessment

Entry assessment

Alternaria gaisen appears to be widespread in China. It forms flecks on young fruit of *P. pyrifolia*, which would be visible pre-harvest. It may also form a post-harvest rot. It is not pathogenic on *P. communis*.

A. yaliinficiens is only known from Hebei. It is known to cause a post-harvest rot of *P. bretschneideri*, and has also not been recorded on *P. communis*. *A. ventricosa* is also only known from *P. bretschneideri*, and only from Hebei. It has only been identified once, from a fruit stem.

Although fruit with lesions are likely to be discarded prior to export, *Alternaria* spp. are known to cause post-harvest rots, which may not be evident during picking or packing of the fruit. The US imports of Chinese *P. bretschneideri* fruit was suspended for several years since the 2001–2002 season due to repeated interceptions of an *Alternaria* spp. disease. Interceptions of similarly decayed fruit were noted in 2001 by plant quarantine authorities in Australia, New Zealand and the United Kingdom (Roberts, 2005). There have been several interceptions at the New Zealand border of *Alternaria* spp. on pear fruit from China (MAFBNZ, 2009).

Given that:

- fruit with symptoms are likely to be detected and discarded during the harvest and packing processes, but

- *Alternaria* spp. may form post-harvest rots;
- there have been interceptions of pear fruit from China with *Alternaria* spp.;
- none of the species are known to be pathogenic on *Pyrus communis*;

The likelihood of entry is considered to be moderate and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be widely distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. The waste material generated could provide an exposure route. The conidia of *Alternaria gaisen* are wind-dispersed. It is assumed that *A. yaliinficiens* and *A. ventricosa* are also wind dispersed. These *Alternaria* species are monophagous, and only infect certain *Pyrus* spp. Exposure of *A. geisen* to suitable hosts (*P. pyrifolia* or its crosses) would require disposal of fruit with conidia in the immediate vicinity of nashi trees/orchards. This species is not widely planted in New Zealand. *A. yaliinficiens* and *A. ventricosa* are only known from *P. bretschneideri* which has a very limited distribution in New Zealand.

Given that:

- the conidia are wind dispersed;
- *P. pyrifolia* is the only available host in New Zealand and is not widespread;

The likelihood of exposure is considered to be very low, but non-negligible.

Establishment assessment

Alternaria gaisen is currently found only within Asia. Infection is favoured by warmer and wetter conditions than are common in the pear production regions of New Zealand. Conidial production is favoured by warm and moist conditions (David, 1964); the optimum conditions for infection of Japanese pear by *A. gaisen* are a relative humidity of 90% or more, and temperatures between 24 and 30°C.

The likelihood of establishment is considered to be very low, but non-negligible.

Consequence assessment

Economic consequences

Alternaria gaisen is monophagous. The only hosts available in New Zealand are *Pyrus pyrifolia* (Asian pear/nashi) and its crosses. In 2002, there were 119 ha of nashi pears grown commercially in New Zealand (Statistics New Zealand, 2002). There are currently *Pyrus pyrifolia* crosses in development; these will be released in approximately two years' time and are expected to be grown on a larger scale than nashi, and to be an alternative to European pears (Mike Butcher, Pipfruit NZ, pers. comm. 17 June 2008). It is unlikely that this fungus would have a large impact on the pear industry due to its warmer climate requirements. However, no management for *Alternaria* spp. currently occurs in pome fruit orchards. There may be implications for New Zealand market access to countries for which *Alternaria* species are actionable.'

The potential economic consequences of establishment are low.

Environmental consequences

Alternaria gaisen is monophagous, only recorded on some *Pyrus* species. This genus contains no New Zealand native species.

The potential environmental consequences of establishment are negligible.

Human health consequences

There are no known human health consequences.

Risk estimation

Several *Alternaria* spp. are known to infect *Pyrus* fruit in China. *Alternaria gaisen* has a moderate likelihood of entry, very low likelihood of exposure, and a very low likelihood of establishment. The potential impact within New Zealand is low, but non-negligible. It is likely that the risk of the unidentified *Alternaria* rots found on exported Ya pear from China is similar to that of the named species discussed here. *As a result the risk estimate for Alternaria spp. is non-negligible and they are classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There is very little information available on *Alternaria yaliinficiens* and *A. ventricosa*. There is significant uncertainty over the ability of all three *Alternaria* species to establish in New Zealand. *Alternaria* species are very variable and identification is difficult. There is uncertainty around the unidentified *Alternaria* rots found on exported Ya pear from China and which species of pear they infect.

5.1.3 Risk management

Options

As there is no information available on *A. yaliinficiens* or *A. ventricosa*, or the species causing the unidentified *Alternaria* rots, this discussion will focus on *A. gaisen*. Risk management measures suitable for *A. gaisen* are likely to be suitable for all *Alternaria* species.

Pest-free areas

A. gaisen is widespread in China, and pest-free areas are unlikely to be a viable option.

Resistant cultivars/species

Extensive screening of *Pyrus* varieties and lines for resistance to *A. gaisen* (*A. kikuchiana*) has found that one pair of genes is involved in the control of response to the pathogen and that resistance is homozygous recessive (Kozaki, 1974). Cultivars of *Pyrus communis*, *P. ussuriensis* var. *sinensis* (Chinese pear) and several wild species have been shown to be resistant (Kozaki, 1973). If resistance can be demonstrated in other *Pyrus* species this may be a viable option.

In-field surveillance

Early publications suggested that *A. gaisen* on Japanese pear was best controlled by applications of Bordeaux mixture (Toyoda, 1965). Later, the main compound used to control *A. gaisen* was Polyoxin B, an antibiotic fungicide (CPC, 2007). Polyoxin B inhibits mycelial development, spore germination, and sporulation of *A. gaisen*. It causes abnormal bulges on the germ tubes and gave better results than conventional fungicides in the field (Eguchi et al, 1968). Polyoxin-resistant strains of *A. gaisen* were first noticed in 1971. Tests of strains from Japan found that tolerance of the fungicide was very stable, persisting after ten transfers on fungicide-free medium (Nishimura et al, 1973). Fuchs (1977) reported that in resistant strains, the synthesis of cell wall chitin was scarcely affected by polyoxin B, and that resistant strains have a reduced capacity to take up polyoxin A or B.

Tolerance of *A. kikuchiana* to the fungicide captafol has been found in Japan (Adachi and Fujita, 1984).

Ma and others (2007) conducted lab and field studies with cultivars of *Pyrus pyrifolia*, using different fungicide concentrations of fungicides. Results showed 50% iprodione wettable powder had the highest capacity for depressing the pathogen; a 2000x solution reduced the pathogen by 100% in the laboratory. In the field, the best fungicide for control of pear scab was also the 50% iprodione wettable powder; its 2000x solution controlled the disease by 87.5%. The 1000x solution of 52.5% Pujunling (a broad-spectrum fungicide) controlled the disease by 85.5%. Eradication of the pathogen was achieved by spraying 300x lime sulphur + 300x solution of 10% sodium pentachlorophenate before bud break (Ma et al, 2007). These results validated previous experiments with trees of *P. pyrifolia*, which showed that applications of 2000x solution of 50% iprodione wettable powder achieved 87.3% control in the field, and applications of 1000x solution of 52.5% Pujunling achieved 85.5% control (Ma et al, 2006).

Much of the work on fungicide resistance appears to have been done in Japan, and it is difficult to assess how much of this would apply to China. However, Huang (2001) found that polyoxin B-resistant mutants of *Alternaria alternata* were generally more sensitive to iprodione, and that iprodione-resistant mutants did not show significant changes in sensitivity to polyoxin B. It is possible that fungicide programs alternating the two would control the build-up of resistance in the field.

Disease symptoms are clearly visible in the orchard. Surveys of export orchard areas would be expected to detect its presence. Symptomatic fruit would indicate the failure of in-field control and any fruit from an infected area should not be permitted entry to New Zealand.

Bagging of fruit

Bagging may not occur until four weeks after fruit set. Bagging would be expected to significantly reduce opportunities for spores to land on fruit.

Phytosanitary inspection prior to export

A. gaisen forms flecks/lesions on young fruit, which would be visible to a post-harvest inspection. It may also form a post-harvest rot, although it is unclear how often this occurs. Given the relatively high temperature requirements of this fungus, post-harvest rots would not progress in transit, and would develop only after being removed from cold-storage. Visual inspection alone is therefore unlikely to be an effective option. However, offshore pytosanitary inspection in combination with bagging is expected to be a viable option.

A combination of fruit bagging, and visual inspection would mitigate the risk to a higher degree than any measure in isolation.

Given the relatively low risk posed by these species no measures in addition to standard commercial practice may be deemed acceptable.

5.2 *Gymnosporangium fuscum – European pear rust*

Scientific name: *Gymnosporangium fuscum* DC., 1805 (Basidiomycota: Urediniomycetes: Uredinales: Pucciniaceae)

Other relevant scientific names: *Gymnosporangium sabinae* (Dicks.) G. Winter, 1880; *Roestelia cancellata* Rebent., 1804; *Tremella sabinae* Dicks., 1785

Common name: European pear rust, trellis rust, juniper rust

5.2.1 Hazard identification

New Zealand status

Gymnosporangium fuscum is not known to be present in New Zealand. Not recorded in: Pennycook (1989), Landcare NZFUNGI (2008) (absent from region), PPIN (2008).

Biology

Like other *Gymnosporangium* species, *G. fuscum* is heteroecious and requires both *Juniperus* and a rosaceous host (*Pyrus*) to complete its life cycle. It causes perennial infection in juniper branches, and under normal circumstances, annual infection in pear leaves (Hunt and O'Reilly, 1978).

Telia are produced on canker-like swellings on juniper stems and branches in the spring. In moist conditions, the telia germinate *in situ* and produce basidiospores that are dispersed and are able to infect nearby pear trees (CPC, 2007).

In Turkey, basidiospore infections occur during the flowering period, from mid April to early May; fruit infections occur only on early ripening varieties of pear (Dinc and Karaca, 1975). The optimum temperature for infection of pear leaves with basidiospores is 15°C, and no infection occurs at or above 25°C (Hilber et al, 1990a). The incubation period on pear leaves is 9–26 days (Dinc and Karaca, 1975). Infection from basidiospores gives rise to pycnia borne on the upper surface of the pear leaves or occasionally on fruit; these are visible from late spring to early summer (CPC, 2007). Leaf infections on pear trees are very obvious (Ormrod et al, 1984). Young infected fruit may become mummified (OEPP/EPPO, 2006).

Later, aeciospores are produced inside aecia on the underside of the leaf. The aeciospores are released when the peridium ruptures and are capable of being wind-borne over long distances to junipers. Leaf or fruit infection of pear does not persist after infected leaves or fruit have fallen, but, unlike most other *Gymnosporangium* species which are annual on their aecial hosts, *G. fuscum* can also form aecial cankers on pear stems, which are perennial, producing aeciospores in successive seasons (CPC, 2007). The perennial cankers give rise to infested shoots with pycnia, or produce aecia directly, and most often die out in the second season. The cankers are probably only produced occasionally, and their survival is poor (Hunt and O'Reilly, 1978).

G. fuscum is the cause of European pear rust, the most important pear rust in Europe (OEPP/EPPO, 2006). The incidence of European pear rust depends on the frequency of the alternate host and the distance between sources of infection and pear orchards (CPC, 2007) and on the susceptibility of pear varieties (Dinc and Karaca, 1975). Pear trees suffer some defoliation, and stem cankers may distort young trees (CPC, 2007), and early fruit drop may result (Gjaerum et al, 2008). There is no indication that *G. fuscum* causes any significant damage to junipers (CPC, 2007).

In Turkey (1970s), incidence varied from 4.26 to 100% and yield losses from 9.69 to 100% (Dinc and Karaca, 1975). The disease is rare and unimportant in northern Europe, where the alternate hosts are relatively infrequent (and temperatures are presumably sub-optimal). In western North America, *G. fuscum* has been more damaging; this is presumably due to the greater frequency of *Juniperus* species (CPC, 2007).

Hosts

The aecial host range of *Gymnosporangium fuscum* is narrow: European pear (*Pyrus communis*) and wild European *Pyrus* species (Farr et al, 2008; Farr et al, 1989; Juhasova and Praslicka, 2002; Grasso, 1963). The telial host under natural conditions is *Juniperus sabina* (from central and southern Europe), and the three Mediterranean species *Juniperus phoenicea*, *J. oxycedrus* and *J. excelsa*. Over much of its present range, it infects, not the natural hosts, but other species such as *Juniperus chinensis* (indigenous to the Far East) and *J. virginiana* (indigenous to North America) (CPC, 2007; Farr et al, 2008). Biosecurity Australia (2005) suggests that this rust is also found on *Pyrus pyrifolia* and *P. bretschneideri*.

Plant parts affected

Aecial hosts: leaves, fruit (Jones and Aldwinckle, 1990); branches (Juhasova and Praslicka, 2002; Grasso, 1963); leaves (Ormrod et al, 1984); upper surface of the pear leaves or occasionally on fruit (CPC, 2007).

Telial hosts: branches (Hilber et al, 1990b).

Geographical distribution

Gymnosporangium fuscum originates in central and southern Europe, where its natural telial hosts occur. The rust now occurs in northern Europe, to which it presumably spread with *Juniperus sabina* cultivation. It has also been introduced to other parts of the northern hemisphere, particularly the west of North America (CPC, 2007). It occurs in north Africa and Asia (CPC, 2007; Farr et al, 2008).

G. fuscum is reported to have a restricted distribution in China (Wang and Guo, 1985); it has been recorded from Shaanxi (Zhuang, 2005). There is no indication that the pathogen is of any importance in China (CPC, 2007).

Hazard identification conclusion

Gymnosporangium fuscum is associated with *Pyrus* fruit and has been recorded in China. It is not known to be present in New Zealand and is considered a potential hazard.

5.2.2 Risk assessment

Entry assessment

Gymnosporangium fuscum apparently has a very limited distribution in China (Shaanxi). It is recorded on *Pyrus communis*, and the main producing area for *Pyrus* sp. nr. *communis* is Xinjiang Province. If the distribution of *G. fuscum* is verified, the likelihood of entry on this species would be negligible. Biosecurity Australia (2005) suggests that this rust is also found on *Pyrus pyrifolia* and *P. bretschneideri*, which are likely to be exported from a wider geographical area, including from Shaanxi and nearby provinces.

It infects the leaves, branches and, less frequently, young fruit of pear. CPC (2007) stated that while fruit can be infected, it is very unlikely that infected fruit would be harvested or meet quality standards for export. The major pathway of entry of this rust is likely to be imported plants/budwood of *Pyrus* or *Juniperus* spp.

Given that:

- *G. fuscum* appears to have a restricted distribution in China;
- there is uncertainty over which species of pears it infects;
- infected fruit is likely to be screened out during the harvest and packing process;

The likelihood of entry is considered to be very low, and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be widely distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. The waste material generated could provide an exposure route. The aeciospores of G*ymnosporangium fuscum* are wind-dispersed. Exposure to suitable hosts would require the disposal of fruit in the vicinity of the alternate host (*Juniperus* species). Although junipers are not used as shelter belts in New Zealand (as they are in countries where this disease is a problem), several species, such as *Juniperus chinensis*, are widely grown as ornamentals (Salmon, 2000).

Given that:

- exposure to an alternate host would be required;
- *Juniperus* spp. only occur as ornamentals in New Zealand;

The likelihood of exposure is considered to be very low, and therefore non-negligible.

Establishment assessment

Gymnosporangium fuscum is a heteroecious rust, and requires *Juniperus* and *Pyrus* to complete its life cycle. In countries where this disease is a problem, the alternate hosts are grown in close proximity. Although large plantings of the alternate hosts do not occur together in New Zealand, both genera are relatively common in ornamental and backyard gardens.

Although this rust is currently restricted to the northern hemisphere, some areas in which it currently occurs have similar climates to areas of New Zealand.

Given that:

- *G. fuscum* requires *Juniperus* and *Pyrus* in close proximity to complete its life cycle;
- these genera are only likely to occur together in garden situations;
- climate is unlikely to be a barrier to it establishing;

The likelihood of establishment is considered to be very low, and therefore non-negligible.

Consequence assessment

Economic consequences

G. fuscum can become a significant pest in pear orchards; however, in countries where this disease is a problem, the alternate hosts are grown in close proximity. Large plantings of the alternate hosts do not occur together in New Zealand and this disease is likely to be of low economic consequence should it establish in New Zealand. In addition it is only known to affect pears. Whilst the impact for individual pear growers might be high, the potential economic impact to New Zealand is considered to be low.
The potential economic impact within New Zealand is very low, but non-negligible.

Environmental consequences

G. fuscum is confined to *Juniperus* and *Pyrus* species. Neither of these genera contains New Zealand native species.
The potential environmental impact within New Zealand is considered to be negligible.

Human health consequences

There are no known human health consequences.

Risk estimation

Gymnosporangium fuscum has a very low likelihood of entry, exposure and establishment. The potential impact within New Zealand is also very low, but non-negligible. *As a result the risk estimate for G. fuscum is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

The distribution of *G. fuscum* within Shaanxi (and potentially in neighbouring provinces) is unknown, as is the incidence of this rust on fruit. The occurrence of *G. fuscum* on *P. pyrifolia* and *P. bretschneideri* is also uncertain.

5.2.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

G. fuscum is reported to have a limited recorded distribution in China (Shaanxi). If this can be verified, in accordance with the requirements set out in ISPM No. 4 or 10 (see Section 4.4) pest free area or place of production may be a viable for some exports.

In-field control (removal of alternate hosts)

Pear rust can be prevented by removing alternate hosts (*Juniperus* spp.) in the vicinity of pear orchards. The disease is only important when alternate hosts are present at a distance of not more than 300 m from the orchard (OEPP/EPPO, 1999).

Ormrod et al, (1984) found that at a distance of 30 m from infected junipers, 100% of pear trees were infected. At 150 m, 50% of pear trees were infected, and at 300 m, all inspected pear trees were free of infection. De Ryck (2001) recommended avoiding the presence of susceptible *Juniperus* species in an area of 500 m around a pear orchard.

A requirement for an appropriate buffer zone for registration of export orchards may be a viable option.

Bagging of fruit

Bagging may not occur until four weeks after fruit set. Young fruit can be infected but bagging would be expected to significantly reduce opportunities for spores to land on fruit. *Pyrus* sp. nr. *communis* fruit are not bagged, but pest free area status may be a viable option for this commodity.

Phytosanitary inspection prior to export

Leaf infections on pear trees are very obvious (Ormrod et al, 1984). While it is unlikely that infected fruit would be harvested or meet quality standards for export, symptomless fruit would be difficult to detect.

Given the relatively low risk posed by this species, no measures in addition to standard commercial practice may be deemed acceptable.

5.3 *Leptosphaeria pomona – fruit rot*

Scientific name: *Leptosphaeria pomona* Sacc., 1876 (Ascomycota: Ascomycetes: Dothideales: Leptosphaeriaceae)
Other relevant scientific names: *Phaeosphaeria pomona* (Sacc.) Huhndorf, 1992
Common names: fruit rot, leaf spot

5.3.1 Hazard identification

New Zealand status

Leptosphaeria pomona is not known to be present in New Zealand. Not recorded in: Landcare NZFUNGI (2008), Pennycook (1989), PPIN (2008).

Biology

There is very little information available on *Leptosphaeria pomona*. The few records that do exist are from the late 1880s to early 1900s (Saccardo, 1883; Sydow, 1897; Yu, 1940).

Only one record was found in a search of CAB abstracts. A survey of pathogens of economic crops in Kiangsu (Jiangsu) Province, China, from 1934 to 1937 noted it as one of two fungi causing fruit rots of 'pear' (Yu, 1940). Crane and Shearer (1991) list (*Leptosphaerella*) *pomona* on the leaves of *Pyrus malus* [=*Malus domestica*]; this refers to the original description of the fungus by Saccardo (1876), in Italy (Shaun Pennycook, Landcare Research, pers. comm., 2008).

Species of *Leptosphaeria* are most often recorded causing spots of leaves, culms and herbaceous stems (e.g. Farr et al, 1989). They are known to infect a wide range of hosts. For example, *Leptosphaeria bicolor* is the cause of leaf-scorch of sugarcane (Punithalingam, 1983). *L. coniothyrium* (anamorph *Coniothyrium fuckelii*) is the cause of a cane blight of raspberry, boysenberry, blackberry and roses. It is spread by air, soil and waterborne-conidia or through wounds (Punithalingam, 1980), and has also been recorded on *Pyrus*, but is not associated with fruit (CPC, 2007).

Leptosphaeria fusispora appears on the dry stems of its hosts, but is not known to cause any pathological symptoms. Ascospores are dispersed by wind and rain-splash; the fungus presumably overwinters on dead host tissue (Chen et al, 2002). *L. protearum* causes a leaf spot, often resembling a leaf blight, on *Protea* species and is probably wind- and splash-dispersed (Taylor and Crous, 1998).

Leptosphaeria maculans causes necrotic lesions and cankers on the stem, roots, bulb and leaves of *Brassica* species. The seed is invaded and dormant mycelium forms beneath the seed coat (Punithalingam and Holliday, 1972). *L. avenaria* f. sp. *avenaria* causes speckle blotch of oats and is seed-borne or wind-borne by ascospores and conidia (Sivanesan, 1971). *L. sacchari* causes ring spot of sugarcane leaves. The fungus persists on old dead leaves and water droplets are required for dispersal (Morgan-Jones, 1967).

Hosts

Malus sylvestris (as *Pyrus malus*) (Farr et al, 2007; Saccardo, 1883; Sydow, 1897); *Prunus persica* var. *vulgaris* (Farr et al, 2008); 'pears' (Yu, 1940).

Plant parts affected

Leaves (Saccardo, 1883); fruit rot (Yu, 1940).

Geographical distribution

Asia: China (Jiangsu Province) (Yu, 1940); Korea (Farr et al, 2008).
Europe: Italy (Farr et al, 2008; Crane and Shearer, 1991).

Hazard identification conclusion

Leptosphaeria pomona has been recorded on the fruit of 'pears' (Yu, 1940). It is present in China. It is not present in New Zealand, and is considered to be a potential hazard.

5.3.2 Risk assessment

Entry assessment

Leptosphaeria pomona has only been recorded once on 'pears' [as '*Leptosphaeria pomica*'], in 1940 (Yu, 1940), the few other records are for *Pyrus malus* [=*Malus sylvestris*]. No recent records exist of this organism at all, suggesting that this is not an important pathogen within its range. Within China, it is only recorded in Jiangsu Province, which is not one of the main pear growing areas.

Leptosphaeria pomona is highly unlikely to enter New Zealand on the *Pyrus* fruit from China pathway.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Leptosphaeria pomona* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for Leptosphaeria pomona is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Assessment of uncertainty

There is almost no information available on this organism; none of it is recent.

5.4 *Macrosporium pyrorum*

Scientific name: *Macrosporium pyrorum* Cooke 1883 (mitosporic fungi)

5.4.1 Hazard identification

New Zealand status

Macrosporium pyrorum is not known to be present in New Zealand. Not recorded in: Pennycook (1989), Landcare NZFUNGI (2008), PPIN (2008).

Biology

There is very little information available on *Macrosporium pyrorum*. The few original records that do exist are from the late 1880s to early 1900s (Saccardo, 1886; Yu, 1940).

Only one record was found in a search of CAB abstracts. A survey of pathogens of economic crops in Kiangsu (Jiangsu) Province, China, from 1934 to 1937 noted it as one of two fungi causing fruit rots of 'pear' (Yu, 1940).

Farr et al, (1989) notes that according to Hughes (1958) the genus *Macrosporium* is considered a synonym of *Alternaria,* but not all names have yet been reallocated. *Alternaria* species such as *A. gaisen* are known to cause fruit rots of *Pyrus* (Jones and Aldwinckle, 1990; Tanaka, 1933).

Simmons (2007) states that the American type specimen cannot be found, and that the description is inadequate to establish the application of this name; "the taxon is unidentifiable without better type information".

Hosts

Pyrus malus [=*Malus sylvestris*] (Farr et al, 2008 – specimen record); *Pyrus serotina* [=*Pyrus pyrifolia*] (Farr et al, 2008); *Pyrus* sp. (Saccardo, 1886; Tai, 1979; Farr et al, 2008); 'pear' (Yu, 1940).

Plant parts affected

Leaves (Saccardo, 1886); fruit rot (Yu, 1940).

Geographical distribution

Asia: China – Jiangsu Province (Tai, 1979; Yu, 1940); Korea (Farr et al, 2008).
North America: USA – specimen record from 1893 (Farr et al, 2008).

Hazard identification conclusion

Macrosporium pyrorum has been recorded on the fruit of pears. It is present in China. It is not present in New Zealand, and is considered to be a potential hazard.

5.4.2 Risk assessment

Entry assessment

Macrosporium pyrorum has been recorded on *Pyrus pyrifolia*. Within China, it is only recorded in Jiangsu Province, which is not one of the main pear producing areas.

There are few records of *M. pyrorum* on pears, other records are of *Pyrus malus* (=*Malus sylvestris*). No recent records exist of this organism at all, suggesting that this is not an important pathogen within its current geographic range.

Macrosporium pyrorum is highly unlikely to enter New Zealand on the *Pyrus* fruit from China pathway.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Macrosporium pyrorum* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for M. pyrorum* is *negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Assessment of uncertainty

There is almost no information available on this organism; none of it is recent. It is also possible that *Macrosporium pyrorum* is a synonym of an *Alternaria* species already considered in this risk analysis.

5.5 *Monilinia fructigena – European brown rot*

Scientific name: *Monilinia fructigena* Honey ex Whetzel, 1945 (anamorph *Monilia fructigena* (Pers.) Pers., 1801) (Ascomycota: Ascomycetes: Helotiales: Sclerotiniaceae)

Other relevant scientific names: *Acrosporium fructigenum* (Pers.) Pers., 1822 [anamorph]; *Oidium fructigenum* (Pers.) J.C. Schmidt, 1817 [anamorph]; *Oidium wallrothii* Thüm., 1875 [anamorph]; *Oospora candida* Wallr., 1833 [anamorph]; *Oospora fructigena* (Pers.) Wallr., 1833 [anamorph]; *Sclerotinia fructigena* Aderh. and Ruhland, 1905, nom. illegit.; *Stromatinia fructigena* (Pers.) Boud., 1907 [anamorph]; *Torula fructigena* Pers., 1796 [anamorph]

Common names: European brown rot, spur canker, blossom blight, wither tip

5.5.1 Hazard identification

New Zealand status

Monilinia fructigena is not known to be present in New Zealand. Not recorded in: Pennycook (1989), Landcare NZFUNGI (2008), PPIN (2008).

Biology

Monilinia fructigena causes brown fruit rot of Rosaceous hosts, particularly of *Malus*, *Pyrus* and *Prunus* species. It can also cause twig blight and canker. Initial infection is via wounds caused by mechanical damage, insect or bird attack or other pathogens (Rekhviashvili, 1975). Birds are the most important wounding agents on pears in the UK. The pathogen can spread via contact between fruits but this is much less important (Xu et al, 2001). Infected fruit are penetrated at wound sites and mycelial growth follows. Tissues in the centre of the fruit rot away, leaving a hollow sphere.

M. fructigena mainly overwinters in or on diseased, mummified fruit, either attached to the tree or on the ground. Other infected tissues such as twigs, peduncles and cankers on twigs or branches on trees may also serve as primary inocula. In the spring or early summer when temperature, day-length and relative humidity are suitable for sporulation, sporodochia form on the surface of the mummified fruit and infected tissues bear chains of conidia (CPC, 2007).

The conidia of *M. fructigena* are dry air spores, which are set free by air currents and wind. The short, unspecialised conidiophores elevate the spore chains above the infected tissues and give better exposure to air currents. The conidia are disseminated by wind when temperatures are high and when relative humidities are low. Rain splashes are also important as a means of liberating spores. Aerial dispersal results in the spread of spores over a wide area, whilst water splash dispersal results in short-range dissemination, mainly to other parts of the same tree or between adjacent trees. Rain splash is thought to be more important than air-borne conidia in initiating infections (Xu et al, 2001). Animals can also be important vectors of this fungus; almost any insect has the potential to pick up and carry spores from sporulating mycelium to healthy, susceptible tissues (CPC, 2007).

Conidia are transported by wind, water or insects to young fruit. The initial infection is always via wounds, usually scab lesions or sites of insect damage, but subsequent spread by contact between adjacent fruit is possible (CPC, 2007).

The first *M. fructigena*-infected fruitlets in pome fruit orchards usually appear approximately 5–6 weeks after full bloom, and subsequently infection of healthy fruit occurs continuously up to harvest time (van Leeuwen et al, 2002). Fruit may become infected at harvest time and then fruit rots develop during the post-harvest period. The mycelia survive long periods of adverse environmental conditions within mummified fruit, twigs, cankers and other infected tissues. When conditions become favourable again, spores are produced on infected tissues and a new cycle of infection is started that coincides with early spring growth of host plants (CPC, 2007).

There are few records of the development of the perfect stage of *M. fructigena*. Apothecia are produced in spring on mummified fruit that have overwintered on the ground; mummified fruit that remain on the tree do not produce apothecia. The release of ascospores coincides with the emergence of young shoots and blossoms of plants (CPC, 2007).

M. fructigena is a pathogen of moist conditions, favoured by rain, fog and other factors that increase humidity, especially at the beginning of the host growth period; this disease is rare in arid climates. Conidia are formed on mummified fruit and blighted twigs at temperatures of >5°C. Sporulation is enhanced by light and the conidia require free moisture for germination (CPC, 2007).

Infections of fruit by conidia usually take place through wounds, although occasionally healthy fruit can be infected by mycelial growth from diseased fruit with which they are in contact. At harvest, apparently healthy fruit can be contaminated with spores, and decay may occur during storage and marketing. In latent infections, the early infection of fruit does not produce symptoms of disease, and further differentiation of the fungus cannot take place until the fruit begins to ripen. Maximum growth and expression of symptoms occurs between 23–27°C, and is significantly retarded above 32°C. There is little development at low temperatures (Roberts and Dunegan, 1932).

Hosts

The major hosts belong to the Rosaceae, particularly *Malus*, *Pyrus* and *Prunus* species (Farr et al, 2008). Recorded hosts include *Pyrus betulifolia* (Tai, 1979); *Pyrus bretschneideri* (AQSIQ, 2007); *Pyrus communis* (Jones and Aldwinckle, 1990; CPC, 2007); *Pyrus pyrifolia* (Tai, 1979; AQSIQ, 2007); *Pyrus* spp., *Pyrus ussuriensis* (Tai, 1979; Farr et al, 2008); *Vitis vinifera* (Tai, 1979).

Plant parts affected

Fruit (Jones and Aldwinckle, 1990; Mordue, 1979); twigs, branches, blossoms, fruit (CPC, 2007); primarily fruit, rarely blossoms and twigs (Farr et al, 2008).

Geographical distribution

Monilinia fructigena is widespread throughout western and southern Europe and extends into the Scandinavian countries, eastern Europe, the former Soviet Union, the Middle and Far East, India, and North Africa (CPC, 2007).

Within China, *M. fructigena* is reported from Anhui (CPC, 2007); Gansu (Zhuang, 2005); Henan, Hubei, Hunan, Jiangsu, Liaoning, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan, Zhejiang) (CPC, 2007).

Hazard identification conclusion

Monilinia fructigena is a pathogen of *Pyrus*, and has been recorded on fruit. It is not present in New Zealand, and is considered to be a potential hazard.

5.5.2 Risk assessment

Entry assessment

Monilinia fructigena is a pathogen of *Pyrus* fruit. It is widespread in China. Apparently healthy fruit can be contaminated with spores at harvest, and decay may occur during storage and marketing. It is assumed that orchard management practices will reduce the prevalence of the pathogen. There is a significant aggregation of diseased fruit on trees (Xu et al, 2001).

Given that:

- *Pyrus* fruit are an important host for *M. fructigena*;
- it is widespread in China, but likely to be reduced to fairly low levels through orchard management;
- some fruit may not develop symptoms until some time after harvest and cold may delay symptoms;
- some fruit may carry spores but remain asymptomatic;

The likelihood of entry is considered to be moderate and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be widely distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. The waste material generated could provide an exposure route.

M. fructigena can be spread by insects, birds, wind and rain splash. The spores are not actively discharged. Pears that developed symptoms after entry into New Zealand and discarded in an open compost heap or in the vicinity of a rosaceous host could provide a source of spores for spread by wind, rain or other vectors. Additionally, discarded asymptomatic pears or uninfected pears carrying spores, if wounded, could develop symptoms and become a source of spores for infection.

M. fructigena has multiple hosts, particularly infecting *Malus*, *Pyrus* and *Prunus*. These trees are widespread in domestic gardens as well as commercial orchards in New Zealand.

Given that:

- asymptomatic pears could be discarded and develop symptoms;
- *M. fructigena* can be spread by insects, birds, wind and rain splash but spores are not actively discharged;
- there is an abundance of hosts widespread in New Zealand;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

The current geographical distribution of *M. fructigena* includes countries with a similar climate to New Zealand (e.g. the UK) and also includes countries with typically colder winters (e.g. Norway) and hotter summers (e.g. Spain). Also, the closely related *M. fructicola* and *M. laxa* are established in New Zealand. *M. fructicola* is widespread and has been recorded in Auckland, Waikato, Hawkes Bay, Wellington, Nelson, mid-Canterbury and Central Otago (Landcare NZFUNGI, 2008). *M. fructigena* has a very similar lifecycle and is likely to have similar temperature requirements. It is likely to establish in similar areas in New Zealand.

Given that:

- climate is unlikely to be a barrier to establishment;
- two closely related fungi are already established in New Zealand;

The likelihood of establishment is considered to be high and therefore non-negligible.

Consequence assessment

Economic consequences

Although *M. fructigena* causes significant losses both before and after harvest, it is not easy to assess the overall losses it causes. Losses can be highly visible to the grower, but are rarely worth the implementation of specific control measures in their own right; the majority of diseased fruit are those that would be rejected anyway for other reasons such as bruising, or bird and insect damage (CPC, 2007).

M. fructigena is less damaging than *M. fructicola* or *M. laxa*, both of which are present in New Zealand (Pennycook, 1989). However it occasionally causes economically important losses of apple and plum fruit in Europe, particularly in hot and humid summers (CPC, 2007).

M. fructegena affects apples and stone fruit as well as pears. There could be some effect on market access to countries currently free of this pathogen.

The potential economic impacts are considered to be moderate.

Environmental consequences

Although *M. fructigena* has been recorded on plant hosts in several families, the major hosts are members of the Rosaceae. There are no New Zealand native members of the primary host genera (*Malus*, *Pyrus* and *Prunus*); however, there may be some effect on New Zealand Rosaceae such as *Acaena*, *Geum*, *Potentilla* and *Rubus* species.

There are no examples of related species of *Monilinia* (*M. fructicola* and *M. laxa*) infecting any New Zealand native species, but this may be due to lack of surveillance (Landcare Research, 2008). Given the wide host-range of the pathogen, damage to New Zealand's environment through infection of native species cannot be excluded but is difficult to estimate.

The potential environmental impacts are uncertain but considered to be low.

Human health consequences

There are no known human health consequences.

Risk estimation

Monilinia fructigena has a moderate likelihood of entry and exposure and a high likelihood of establishment in New Zealand. The potential economic impact is moderate. *As a result the risk estimate for M. fructigena is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

It is not clear how likely it is that uninfected fruit will carry spores and will enter New Zealand, or how viable spores on uninfected fruit are. It is not clear how fast infected fruit will develop symptoms, especially under refrigerated transport. It is uncertain how effective the passive discharge of spores will be on discarded fruit at ground level.

5.5.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest-free area

M. fructigena is not recorded from Xinjiang which is the main growing area for *Pyrus* sp. nr. *communis.* Furthermore it is not a problem in arid areas. Pest free area status may be an option for these pears, if this distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4). This assumes that that the level of surveillance for the pathogen is such that it would be detected if it was present.

In-field control and surveillance

M. fructigena can be carried as spores on uninfected fruit or fruit that are infected but asymptomatic at the time of packing. Additionally, as *M. fructigena* can be wind-transmitted, these spores could have been derived from other orchards or vineyards under a different regime of pathogen management. Disease symptoms are clearly visible in the orchard (circular brown spots on fruit and mummified fruit). Surveys of export orchard areas would be expected to detect its presence, and any fruit from an infected area should not be permitted entry to New Zealand.

Bagging of fruit

Bagging may not occur until four weeks after fruit set. Fruit can be infected from flowering onwards but bagging would be expected to significantly reduce opportunities for spores to land on fruit. *Pyrus* sp. nr. *communis* fruit are not bagged, but pest free area status may be a viable option for this commodity.

Phytosanitary inspection prior to export

Primary infection by *M. fructigena* is through wounds and wounded fruit will be visible at harvest and packing; however, latent infections may occur and rots may appear during storage and marketing. Xu and Robinson (2000) demonstrated that the average incubation time of *M. fructigena* was slightly dependent on temperature but was around 10–11 days. Sea freight to New Zealand exceeds this but air freight does not. Therefore, inspections at the New Zealand border could be a useful option for sea freighted produce but not for air freighted produce. However, offshore visual inspection in combination with bagging and in-field control and surveillance, whereby fruit from infected orchards are not permitted to be exported is expected to be a viable option.

It is difficult to distinguish *M. fructicola* and *M. laxa* (both present in New Zealand) from *M. fructigena*. PCR-based identification protocols for quarantine purposes have been developed for *M. fructicola* (Ma et al, 2003), *M. laxa* (Ma et al, 2005) and *M. fructigena* (Ioos and Iancu 2008). These were investigated by Fan and others (2007). Some protocols were acceptable for *M. fructicola* and *M. laxa* but unfortunately all protocols investigated resulted in some misidentifications of *M. fructigena* and therefore may not be suitable for quarantine purposes at this stage.

A morphological method of identifying *M. fructigena* has been developed by Lane (2002) and may be the most suitable method of identifying *M. fructigena* to the species level at this stage (Lane 2002).

Cold treatment

Although *M. fructigena* does not sporulate in the absence of light, and mycelial growth is likely to cease at the temperatures at which pears from China are shipped, cold storage will not kill the pathogen. This is not considered a viable option.

5.6 *Mycosphaerella pyri (anamorph Septoria pyricola) – leaf fleck of pear*

Scientific name: *Mycosphaerella pyri* (Auersw.) Boerema, 1970 (anamorph *Septoria pyricola* (Desm.) Desm., 1850) (Ascomycota: Ascomycetes: Dothideales: Mycosphaerellaceae)

Other relevant scientific names: *Septoria pyri* Castagne [anamorph]; *Sphaerella pyri* Auersw., 1869

Common names: leaf fleck of pear, white spot of pear, pear leaf spot, white leaf spot

5.6.1 Hazard identification

New Zealand status

Mycosphaerella pyri (anamorph *Septoria pyricola*) is not known to be present in New Zealand. Not recorded in: Landcare NZFUNGI (2008), Pennycook (1989), PPIN (2008).

Biology

Mycosphaerella pyri is mainly confined to the foliage. It causes spots, about 3 mm in diameter to appear on the upper leaf surface. The spots are grey-white with purplish margins, sharply defined margins and small, black, scattered pycnidia in their centres. Occasionally, the dead tissue in the spots falls out, giving a shot-hole appearance to the leaves. In serious cases of infection, leaves fall in late summer (Jones and Aldwinckle, 1990).

The primary infection of leaf fleck of pear originates from the ascospore stage of the causal fungus, *Mycosphaerella pyri* (Muller, 1951). The fungus overwinters in dead leaves as ascomata and the primary infection develops from the ascospores. Pycnidia are not formed on overwintered leaves. Ascospores are discharged during spring and the sporulation period is brief, a few rainy days being sufficient for completion (Sivanesan, 1990). The optimum temperature for germination of ascospores is about 21°C (Muller, 1951).

Schwabe and Knox-Davies (1966) describe experiments conducted on leaves in glasshouses to determine germination rates of pycnidia already present on the leaves. The experiments did not assess dispersal from leaves, but the authors speculated that picnidia on freshly infected leaves may be important in disseminating the disease to other leaves during the dry summers of the South-Western Cape of South Africa.

Conidia reportedly play a part in dissemination during summer and direct infection of pear fruit by conidia may occur, reducing their vitality and yield (Sivanesan, 1990). The only reports of conidia infecting pear fruit are from Italy, and South Africa (Florenzano, 1946; Louw, 1948). In Italy, only one cultivar of *P. communis* (Coscia) was affected and one cultivar (Beurre Bosc) was affected in South Africa. Pear fruit are only reported being infected in locations of high humidity. Isolates from fruit have germinated in the lab, at 22°C and high humidity. There appears to be no evidence that picnidia over-winter. The numbers of picnidia on fruit are very small, 1-15 per lesion, compared with 1, 600 per cm^{-2} ascomata over-wintering on dead leaves (Florenzano, 1946).

The fungus is spread by windborne ascospores and conidia (Sivanesan, 1990).

Hosts

Pyrus spp. (Sivanesan, 1990); *P. communis* (Farr et al, 1989; CPC, 2007; Chavez-Alfaro et al, 1995); *P. pyrifolia* (Tai, 1979; Farr et al, 1989; Farr et al, 2007); *P. bretschneideri* (Tai, 1979; Farr et al, 2007; AQSIQ, 2007); *Pyrus callyerana*, *Pyrus ussuriensis*, *Pyrus* spp. (Tai, 1979).

Some resistance to *M. pyri* has been found in the genus *Pyrus*, e.g. *P. calleryana* has been found to be highly resistant (Singletary, 1966; Overcash, 1960).

There are some reports of infection of *Malus*. These are likely to be of *Sphaeria sentina*, a different fungus described from apple leaves (Sivanesan, 1990). In addition, Tai (1979) lists *Prunus armeniaca* as a host.

Plant parts affected

Leaves (Chavez-Alfaro et al, 1995; Muller, 1951; Schwabe and Knox-Davies, 1966); fruit, leaves (Farr et al, 1989; Sivanesan, 1990; Florenzano, 1946; Louw, 1948).

Geographical distribution

Asia: China (Sivanesan, 1990; AQSIQ, 2007); India, Iran, Nepal, Taiwan (Sivanesan, 1990).
Europe: Austria, Belgium, France, Germany, Great Britain, Hungary, Italy, Netherlands, Rumania, Spain, Switzerland, Turkey, USSR, Yugoslavia (Sivanesan, 1990).
North America: USA (Sivanesan, 1990). **Africa:** South Africa (Sivanesan, 1990).

Hazard identification conclusion

Mycosphaerella pyri is a pathogen of *Pyrus*, and has been recorded on fruit. It is present in China. It is not present in New Zealand, and is considered to be a potential hazard.

5.6.2 Risk assessment

Entry assessment

Species of *Mycosphaerella* known to attack pears tend to be only found on the leaves (Podleckis and Usnick, 2005). There have been irregular reports of *M. pyri* on fruit of 2 cultivars of *Pyrus communis*. There is no evidence that pear fruit of the species and cultivars grown in China develop lesions. However, if they were to do so, the lesions are very obvious and symptomatic fruit are likely to be removed during harvesting and packing operations.

Given that:

- *Mycosphaerella* pyri tends to be only found on the leaves;
- any infected fruit that may occur are likely to be removed during harvesting and packing operations;
- ascospores form the primary inoculum, and are formed on dead leaves during winter. They do not occur on fruit.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Mycosphaerella pyri* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for M. pyri is negligible and it is not classified as a hazard. Therefore risk management measures are not justified.*

5.7 *Phomopsis fukushii – Japanese pear canker*

Scientific name: *Phomopsis fukushii* Endo and Tanaka, 1927 (mitosporic fungi)
Common names: Japanese pear canker, phomopsis canker

5.7.1 Hazard identification

New Zealand status

Phomopsis fukushii is not known to be present in New Zealand. Not recorded in: Pennycook (1989), Landcare NZFUNGI (2008), PPIN (2008).

Biology

Phomopsis fukushii was first described from Japan, as a disease of Japanese pears affecting the stems and branches of the trees, especially those over ten years old (Endo, 1927). Nasu and others (1987) subsequently reported a *Phomopsis* rot of fruit of *Pyrus ussuriensis* (blossom end rot) and *P. pyrifolia* (core rot), also in Japan. They concluded that the causal agent of the pear rots was *P. fukushii* and that fruit rot is one of the symptoms of pear canker.

Infection of *P. communis* and *P. bretschneideri* results in blossom end rot, while the Japanese pear cultivar Atago (*P. pyrifolia*) develops core rot. Pale brownish spots initially appear on the calyx end of fruit and expand. In severely infested fruit, brownish spots cover the entire calyx end with white velvet-like mycelia and small black pycnidia. Symptoms were induced around harvest time and bagging effectively prevented the disease (Nasu, 2005).

The perfect state of *P. fukushii* has been found in the bark of pear trees in Japan. Perithecia were deeply immersed in the bark tissue while pycnidia were formed near the surface. Single-ascospore isolates were shown to be infective. From the morphological characteristics of the perithecia, ascospores and asci, Fukutomi and others (1991) identified the fungus as *Diaporthe medusaea*. This association of anamorph (*P. fukushii*) and teleomorph (*D. medusaea*) has not been subsequently validated, and is not supported by Murali and others (2006), who found that isolates of *P. fukushii* and *D. medusaea* did not group together using molecular methods to resolve phylogeny.

Hosts

Monophagous.
Pyrus ussuriensis (Nasu et al, 1987; Tai, 1979), *Pyrus* spp. (Tai, 1979); *Pyrus pyrifolia* (AQSIQ, 2007; Endo, 1927; Nasu et al, 1987); *Pyrus communis* (CPC, 2007; Nasu, 2005); *Pyrus bretschneideri* (AQSIQ, 2007; Nasu, 2005).

Plant parts affected

Bark (Fukutomi et al, 1991); fruit (Nasu, 2005; Nasu et al, 1987); stems, branches (Endo, 1927).

Geographical distribution

Asia: China (Zhang and Huang, 1990; Zhuang, 2005); Japan (Endo, 1927; Nasu et al, 1987); Korea, Taiwan (Farr et al, 2008).

Within China, *P. fukushii* has been recorded only in Gansu (Zhuang, 2005).

Hazard identification conclusion

Phomopsis fukushii is a pathogen of *Pyrus*, and has been recorded on fruit. It is present in China. It is not present in New Zealand, and is considered to be a potential hazard.

5.7.2 Risk assessment

Entry assessment

Phomopsis fukushii appears to be mainly confined to Japan, and has only been recorded from Gansu in China. Although it can be associated with pear fruit, it is unlikely to be prevalent in China. Symptoms are likely to be obvious and infected fruit discarded during harvest and packing processes.

The likelihood of entry is considered to be very low, but non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be widely distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. The waste material generated could provide an exposure route.

Phomopsis fukushii appears to be monophagous, infecting only *Pyrus* species. *Phomopsis* species are generally spread by water and wind-borne rain. Exposure to suitable hosts (*Pyrus* spp.) would require disposal of infected fruit in the immediate vicinity of pear trees/orchards in New Zealand.

The likelihood of exposure is considered to be low, but non-negligible.

Establishment assessment

Phomopsis fukushii occurs mainly in Japan. The climate requirements for this fungus are unknown. Given the current restricted distribution, it is unlikely to be a highly invasive species.

The likelihood of establishment is considered to be low, but non-negligible.

Consequence assessment

Economic consequences

Phomopsis fukushii is a monophagous fungus. Hosts available in New Zealand include *Pyrus communis* and *P. pyrifolia* and its crosses. Whilst the impact for individual pear growers might be high, the potential economic impact to New Zealand is considered to be low

The size of the New Zealand pear industry (*Pyrus communis*) was 412 ha in 2008 (Pipfruit New Zealand, 2008). There is no recent available information on the size of the nashi industry in New Zealand. In 2002, there were 119 ha of nashi (*Pyrus pyrifolia*) grown commercially in New Zealand (Statistics New Zealand, 2002). This is likely to have declined in line with the European pear industry, which has more than halved since 2002 (from 965 ha in 2002 to 412 ha in 2008) (Pipfruit New Zealand, 2008).

It is unlikely that this fungus would have a large impact on the pear industry. It was first recorded in Japan in 1927, and given that the distribution continues to be restricted, it may have specific climate requirements and is unlikely to be a highly invasive species.
The potential economic impacts are considered to be low.

Environmental consequences

Phomopsis fukushii is monophagous, only recorded on *Pyrus* species. This genus contains no New Zealand native species.

Human health consequences

There are no known human health consequences.

Risk estimation

Phomopsis fukushii has a very low likelihood of entry and a low likelihood of exposure and establishment in New Zealand. The potential economic impact within New Zealand is low. *As a result the risk estimate for P. fukushii is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There is very little information available on *Phomopsis fukushii*. All the literature on this fungus is from Japan and there is no information on its impact. It is also unknown where in China it is distributed.

The identity of the fungus, both the record in China and the records in Japan, is uncertain. The teleomorph has been identified as *Diaporthe medusaea*, however, this is dubious. Because of a high degree of character plasticity, morphological and cultural characters cannot be relied upon for delimiting species in *Phomopsis* (Murali et al, 2006). Many studies have concluded that pathogenic *Phomopsis* spp. are not host-specific and that the species concept needs to be redefined (Murali et al, 2006).

5.7.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest-free area

Although the distribution of *P. fukushii* in China is largely unknown, available information suggests that its distribution is restricted and this may be a viable option if its distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

Bagging of fruit

Nasu (2005) found that bagging of fruit effectively prevented the disease. Bagging of pear fruit on the tree in export orchards is routine in all the main pear growing provinces for *Pyrus bretschneideri* and *P. pyrifolia* (Hebei, Shandong, Shaanxi, Shanxi, Gansu, Liaoning, Jilin, Beijing, Henan, Anhui). *Pyrus* sp. nr. *communis* from Xinjiang Autonomous Region are not bagged.

Phytosanitary inspection prior to export

Symptoms are induced around harvest time (Nasu, 2005). The rots are obvious and are likely to be visible to the naked eye.

Given the relatively low risk posed by this species, no measures in addition to standard commercial practice may be deemed acceptable.

5.8 *Venturia nashicola – Japanese pear scab*

Scientific names: *Venturia nashicola* S. Tanaka and S. Yamam., 1964 (anamorph *Fusicladium nashicola* K. Schub. and U. Braun, 2003) (Ascomycota: Ascomycetes: Dothideales: Venturiaceae)
Common names: Japanese pear scab, black spot

5.8.1 Hazard identification

New Zealand status

Venturia nashicola is not known to be present in New Zealand. Not recorded in: Landcare NZFUNGI (2008), Pennycook (1989), PPIN (2008), Brewer and others (2005) (absent from New Zealand).

Taxonomy

Much of the available research has synonymised *Venturia nashicola*, the scab fungus of Japanese and Chinese pears (*Pyrus pyrifolia* and *P. ussuriensis*), with *V. pyrina*, the scab fungus of European pears (*P. communis*). Recent molecular (Le Cam et al, 2002) and biochemical (Isshiki et al, 2000) work has found that this synonymy is incorrect. Morphological examination has found that the ascospores of *V. pyrina* are longer and wider than those of *V. nashicola* and the conidia of *V. nashicola* significantly shorter than those of *V. pyrina* (Ishii and Yanase, 2000). In addition, *V. nashicola* is only pathogenic on Japanese and Chinese pears and *V. pyrina* is only pathogenic on European pear (Ishii and Yanase, 2000; Tanaka andYamamoto, 1964).

Schubert and others (2003) note that the data available are not sufficient to determine whether the fungi are two distinct species or two races of a single species. However, given the morphological differences, they preferred to keep two separate species.

Biology

Venturia nashicola is an economically important disease in China, especially in traditional Chinese pear varieties (Li et al, 2007b), and can result in more than 30% yield loss (Lian et al, 2007). It causes scab lesions on the leaves, young shoots and fruit. Leaves and fruit become gradually less susceptible as they age (Li et al, 2007a). Generally, the life-cycle of *V. nashicola* is similar to that of *V. inaequalis* (apple scab) (Lian et al, 2007).

V. nashicola can overwinter in buds of pear trees as dormant mycelia, forming scab lesions on the young shoots in early spring (Lian et al, 2007). Conidia (asexual spores) are considered the main source of inoculum in primary and secondary infection in most areas of north China, and are present throughout the growing season (Li et al, 2007b). The conidia are dispersed by rain-splash (Lian et al, 2007). Conidial germination and infection of pear leaves can take place from 5–30°C, with an optimum temperature of 20°C. Conidia need a minimum of six hours of continuous wetness to infect leaves at 20°C (Lian et al, 2007).

Ascospores (sexual spores) are formed in pseudothecia on fallen leaves and provide an overwintering mechanism for the fungus, as well as a means of genetic exchange. They are an important source of primary inocula in the early season. In northern China, ascospores begin to mature and are discharged from early April until late June, with a peak in May (Lian et al, 2007). The discharge of ascospores from pseudothecia requires free water or 100% relative humidity. A period of soaking in water as short as ten seconds is sufficient to initiate the discharge of ascospores; most ascospores (ca. 80%) were discharged within the first hour. Like the conidia, ascospores germinate from 5–30°C, with an optimum of 20°C (Lian et al, 2007).

Hosts

Pyrus aromatica (= *P. ussuriensis*), *P. betulifolia* (Farr et al, 2008); *Pyrus bretschneideri* (Farr et al, 2007; Brewer et al, 2005); *P. lindleyi* (= *P. ussuriensis*) (Farr et al, 2008); *Pyrus pyrifolia* (Umemoto, 1992; Brewer et al, 2005); *P. serotina* (= *P. pyrifolia*), *P. ussuriensis* (Ishii and Yanase, 2000); *P. ussuriensis* var. *sinensis* (Farr et al, 2008).

Plant parts affected

Leaves (Farr et al, 2007; Li et al, 2007a; Schubert et al, 2003); fruit (Brewer et al, 2005; Li et al, 2007a).

Geographical distribution

Asia: China (Farr et al, 2007; Wei and Gao, 2002); Japan, Korea, Taiwan (Farr et al, 2008).

Likely to be widespread in pear-growing areas of China; specifically recorded from Shandong, Shanxi (Li et al, 2007b); Shaanxi (Li et al, 2007a).

Hazard identification conclusion

Venturia nashicola is a pathogen of *Pyrus*, and has been recorded on fruit. It is present in China. It is not present in New Zealand, and is considered to be a potential hazard.

5.8.2 Risk assessment

Entry assessment

In China, *Venturia nashicola* is controlled mainly by routine application of fungicides (Lian et al, 2007; Li et al, 2007a). Orchard sanitation measures such as the application of lime, lime-sulphur and urea to leaf litter on the orchard floor, and the shredding of fallen leaves, has proven very effective in reducing the potential ascospore dose of *V. pyrina* and *V. inaequalis* (Lian et al, 2007). The incidence in orchards managed for export is likely to be low.

Scab lesions of *V. nashicola* are restricted to the surface of fruit. The fruit are infected at a young age and the scabs are obvious at harvest and packing.

Given that:

- *V. nashicola* is expected to have low prevalence;
- there is uncertainty about which species of *Pyrus* are hosts;
- infected fruit are likely to be screened out during the harvest and packing process;

The likelihood of entry is considered to be low, but non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be widely distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. The waste material generated could provide an exposure route.

Venturia nashicola is monophagous, infecting only Asian pear species. Conidia are formed on the fruit and are spread by water and wind-borne rain. Exposure to a suitable host (*Pyrus pyrifolia*) would require disposal of infected fruit underneath or in the immediate vicinity of a nashi tree or orchard.

The likelihood of exposure is considered to be low, but non-negligible.

Establishment assessment

The closely related *Venturia pyrina* is established in New Zealand, and has been recorded on *Pyrus communis* in Auckland, Waikato, Hawkes Bay, Wellington, Nelson and Dunedin (Landcare NZFUNGI, 2008). *Venturia nashicola* has a very similar lifecycle and temperature requirements and is likely to establish wherever *Pyrus pyrifolia* is grown in New Zealand.

The likelihood of establishment is considered to be high.

Consequence assessment

Economic consequences

Venturia nashicola only infects Asian pears. The only hosts available in New Zealand are *Pyrus pyrifolia* (Asian pear/nashi) and its crosses. In 2002, there were 119 ha of nashi grown commercially in New Zealand (Statistics New Zealand, 2002). There are currently *Pyrus pyrifolia* crosses in development, these will be released in approximately two years time and are expected to be grown on a larger scale than nashi, and to be an alternative to European pears (Mike Butcher, Pipfruit NZ, pers. comm. 17 June 2008).

Venturia nashicola is an economically important species in China. Should it become established in New Zealand it is likely to have some impact on the nashi industry, similar to the impact that the very closely related species (*Venturia pyrina*) has on the European pear industry in New Zealand. Whilst the impact for individual pear growers might be high, the potential economic impact to New Zealand is considered to be low.
The potential economic impacts are considered to be low.

Environmental consequences

Venturia nashicola is monophagous, only recorded on *Pyrus* species. This genus contains no New Zealand native species.

Human health consequences

There are no known human health consequences.

Risk estimation

Venturia nashicola has a low likelihood of entry, and exposure and high likelihood of establishment in New Zealand. The potential impact within New Zealand is low. *As a result the risk estimate for Venturia nashicola is non-negligible and it is classified as a hazard.*
Therefore risk management measures can be justified.

Assessment of uncertainty

It is uncertain whether *Venturia nashicola* and *V. pyrina* (present in New Zealand) are two distinct species or two races of a single species. It is uncertain whether *Pyrus* sp. nr. *communis* is a host of *Venturia nashicola.*

5.8.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

Venturia nashicola is not recorded from Xinjiang which is the main growing area for *Pyrus* sp. nr. c*ommunis.* Available information suggests that its distribution in the rest of China is restricted and this may be a viable option if its distribution can be verified.

Bagging of fruit

There is no information to suggest that bagging of fruit has an effect on the incidence of Japanese pear scab.

Phytosanitary inspection prior to export

Scab lesions of *V. nashicola* are restricted to the surface of fruit. The fruit are infected at a young age and the scabs are visible to the naked eye.

Given the relatively low risk posed by this species and the uncertainty about its identity, no measures in addition to standard commercial practice may be deemed acceptable.

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6 Risk analysis of potential hazard organisms: Insecta: Coleoptera

6.1 *Harmonia axyridis* – harlequin ladybird

Scientific name:	*Harmonia axyridis* (Pallas, 1773) (Coleoptera: Coccinellidae)
Other relevant scientific names:	*Coccinella axyridis* Pallas
Common names:	harlequin ladybird, multicoloured Asian ladybird

6.1.1 Hazard identification

New Zealand status

Harmonia axyridis is not known to be present in New Zealand. Not recorded in PPIN (2008).

Biology

Harmonia axyridis is considered bivoltine in much of Asia, North America and Europe, although in favourable conditions it can be multivoltine and up to four or five generations per year have been observed (Koch, 2003).

The life-cycle of *H. axyridis* consists of egg, four larval instars, pre-pupa, pupa and adult (CPC, 2007). Pairing takes place 5–6 days after adult emergence, and oviposition 2–5 days later. Pairing continues throughout the life of the female and unfertilised females lay sterile eggs. Eggs are laid in irregular masses, which are usually found on the lower surface of leaves infested with aphids (Tan, 1933).

An adult produces 20–50 eggs per day and the development of the immature stages is dependent on a variety of factors including temperature and diet. In temperate regions, the egg stage will take 4–5 days, the larval stage about three weeks and the pupal stage one week. Adults typically live for a year. Adult ladybirds are reproductively active for about three months (CPC, 2007). Fan and Yang (1983) found that in Liaoning, China, the oviposition period lasted 12–16 days and each female laid an average of 200 eggs.

H. axyridis is a highly mobile species. Adults fly readily between host plants during breeding periods, seeking high-density aphid populations. In Asia and America, it migrates over long distances to and from dormancy sites: adults spend the winter months in a state of dormancy in large aggregations. In the spring, they undertake another dispersal flight to seek food and suitable host plants on which to breed; this may result in a considerable increase in their distribution (CPC, 2007).

Hosts

Harmonia axyridis is not usually a plant pest, instead a generalist predator of insects, such as the green peach aphid, *Myzus persicae* (Wang and Shen, 2007). Since its prey sometimes feed on fruit, it is also likely to occur on fruit. In autumn, adult *H. axyridis* have been reported aggregating on, and in some cases feeding on, fruits such as apples, pears, and grapes (quoted in Koch, 2003).

H. axyridis has been intercepted on imported *Pyrus bretschneideri* fruit (MAFBNZ, 2009).

Geographical distribution

H. axyridis is native to central and eastern Asia, where it is a well-known predator of aphids (Koch, 2003). It has been introduced as a classical biological control agent to a number of countries within Europe and the USA, Canada and South America (CPC, 2007). It has also been recorded from Egypt.

It is native to China, and widespread. It is recorded in Fujian (Guan et al, 2007), Heilongjiang, Jilin, Liaoning, Inner Mongolia, Hebei, Henan, Shanxi, Shandong, Shaanxi, Ningxia, Gansu, Hubei, Jiangsu, Jiangxi, Zhejiang, Fujian, Guangdong, Hunan, Guangzhou, Guizhou, Sichuan, Yunnan, Hong Kong, Xingjiang (Hua, 2000).

Hazard identification conclusion

Harmonia axyridis is associated with *Pyrus* fruit. It is present in China, is not present in New Zealand, and is considered to be a potential hazard.

6.1.2 Risk assessment

Entry assessment

H. axyridis is predominantly a predator of other insect species. The adults are sometimes associated with soft fruit in the absence of prey in the autumn (CPC, 2007). While adults are highly mobile, and thus might be expected to fly away during picking, *H. axyridis* has been intercepted alive at the New Zealand in 2004 on imported *P. bretschneideri* fruit from China (MAFBNZ, 2009), so this species is able to survive existing harvesting, processing and transit procedures and conditions. This insect is used as a biocontrol agent in China so it is likely to be widespread in orchards.

Despite numerous intentional releases for classical biological control, it is suggested that the current population in North America stemmed from accidental seaport introductions (Koch, 2003).

Given that:

- adults are the lifestage likely to be associated with harvested fruit and they are mobile and visible; but
- *H. axyridis* is assumed to be widespread in orchards in China;
- *H. axyridis* has been intercepted on imported fruits from China;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed throughout New Zealand’s city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. Infested fruit are more likely to be thrown away. The waste material generated could allow some *H. axyridis* adults to disperse and find a suitable host. Adults are highly mobile; they can fly well and locate plants heavily infested with aphids (CPC, 2007). They would be able to move off any infested fruit disposed of in the environment in New Zealand. *H.*

axyridis is a generalist predator feeding on widely distributed insects such as *Myzus persicae* (Wang and Shen, 2007), found on a wide range of plants. Aphids such as *Aphis gossypii* and *Myzus persicae* are known to be present on native as well as introduced plant hosts in New Zealand (Spiller and Wise, 1982). There should be no lack of suitable prey species for this ladybird in a wide range of habitats.

Given that:

- adults are highly mobile;
- adults are generalists predators and there would be no shortage of suitable prey available;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

Since ladybirds reproduce sexually, a mated female or at least one individual of both sexes would be necessary to establish a reproductive population.

H. axyridis is primarily a polyphagous arboreal species that inhabits orchards, forest stands and old-field vegetation. It thrives and breeds in agricultural habitats, such as forage crops, maize, soyabean and wheat and conifer woodland. This ability to exploit a diverse range of habitats suggests that *H. axyridis* has the potential to spread and invade a wide range of ecosystems (CPC, 2007).

The wide latitudinal and longitudinal range of *H. axyridis* in its native range in Asia shows that it can develop and breed in both warm and cool climes. This is further supported by the establishment and spread of *H. axyridis* in the USA from sub-tropical Florida in the south to cold temperate regions of Canada in the north. *H. axyridis* is tolerant of winter temperatures below freezing and summer temperatures of 30°C (CPC, 2007). Climex modelling indicates that New Zealand seems highly suitable for long-term survival of *H. axyridis* (Poutsma et al, 2008).

Despite numerous intentional releases for classical biological control, initial introductions of *H. axyridis* to USA agroecosystems failed to establish (CPC, 2007), and it is suggested that the current population in North America stemmed from accidental seaport introductions (Koch, 2003). Once established, *H. axyridis* rapidly colonised the USA; just two years after it had initially established in Georgia, its spread was documented throughout the entire state and into the neighbouring states of Florida and South Carolina. This rapid dispersal ability, polyphagous nature and low habitat/host plant specificity, will aid the spread of this beetle (CPC, 2007).

Given that:

- a mated female or at least one individual of both sexes would be necessary to start a reproducing population;
- *H. axyridis* thrives in a range of habitats and has rapid dispersal ability;
- Climex modelling indicates that conditions in New Zealand are suitable for establishment; but
- initial deliberate introductions into the US for biological control failed to establish;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

H. axyridis has been used as a classical biological control agent in North America and Europe, preying on a wide variety of tree-dwelling homopteran insects, such as aphids, psyllids, coccids, adelgids and other insects. In North America, *H. axyridis* offers effective control of target pests, such as aphids in pecans, *Aphis spiraecola* in apple orchards and several citrus pests (Koch, 2003). *H. axyridis* may therefore prove to be beneficial to crop systems through a reduction in aphid numbers below economically damaging levels and thus an associated reduction in the use of chemical pesticides (CPC, 2007). In contrast, it is also reported feeding on fruits such as apples, pears and grapes blemishing the fruit. In vineyards, they are hard to remove from clusters of grapes and so get crushed during harvest and crop processing and the toxic alkaloids contained within the insects can taint the vintage (quoted in Koch, 2003).

The potential economic consequences are considered positive to a low level.

Environmental consequences

H. axyridis is a polyphagous predator and has been used widely as a biological control agent of pest aphids and scale insects. Evidence is building to indicate that *H. axyridis* has negative effects on native Coccinellidae. It appears to be a top predator in the guild of aphidophagous insects and may use other aphidophagous insects as a food source (Koch, 2003). It therefore poses a serious risk to native biodiversity (CPC, 2007). During the past 20 years, it has successfully invaded non-target habitats in North America, Europe and South America in a short period of time, attacking a wide range of non-pest species in different insect orders (Poutsma et al, 2008).

The potential environmental consequences are considered negative to a moderate level.

Human health consequences

During the fall migrations *H. axyridis* adults form mass aggregations and like to land on white or light-coloured objects, such as buildings. Aggregation sites are often homes and the beetles then make their way inside the buildings (Koch, 2003). When frightened or squashed, they leave stains of bodily fluids with an unpleasant odour (Weeden et al, 1996). They also may swarm and land on people (Weeden et al, 1996). They have been reported to bite humans and some people have developed an allergic rhinoconjunctivitis (Goetz, 2007). *H. axyridis* sometimes overwinters in beehives, where it is a nuisance to the beekeepers, but not harmful to the bees (Koch, 2003).

The potential human health consequences are considered low.

Risk estimation

Harmonia axyridis has a low likelihood of entry, moderate likelihood of exposure and moderate likelihood of establishment in New Zealand. The potential impact within New Zealand is uncertain; there may be a positive effect on agriculture and cropping systems and a negative effect on biodiversity. *As a result the risk estimate for H. axyridis is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There is uncertainty around about the level of association between *H. axyridis* adults and pear fruit. On the basis of a border interception record and its biology and behaviour it is assumed to be low. There is uncertainty over the ecosystem effects of generalist predators; on the basis of evidence from other countries it is assumed that it would be non-negligible in New Zealand.

6.1.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

Harmonia axyridis is native to China and widespread. Pest-free area status is unlikely to be a viable option.

Bagging of fruit

Fruit are bagged up to one month after fruit set (see section 2.2.3 and section 4.4). *H. axyridis* adults are relatively large, 5–8 mm long and 4–6.5 mm wide. The practice of bagging individual fruit is likely to prevent adults from accessing the fruit surface. However, the border interception on pears from China suggests that bagging is not always effective. Furthermore, *Pyrus* sp. nr. *communis* fruit are not bagged and this will not be a viable option for these fruit.

Phytosanitary inspection prior to export

Adults may be associated with fruit. They are relatively large (5–8 mm long and 4–6.5 mm wide) and brightly coloured; the elytra range from yellow-orange to red with 0 to 21 black spots, or may be black with red spots (CPC, 2007). Visual inspection is likely to detect *H. axyridis*.

Cold treatment

H. axyridis is tolerant of temperatures below freezing; cold treatment at temperatures that will not damage the commodity are unlikely to be an effective risk management measure.

Airbrushing

High pressure air brushing during packing is expected to remove adults from fruit.

A combination of fruit bagging, airbrushing and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

6.2 *Rhynchites auratus – cherry weevil*

Scientific name: *Rhynchites auratus* (Scopoli, 1763) (Coleoptera: Attelabidae)
Common names: apricot weevil, cherry weevil

6.2.1 Hazard identification

New Zealand status

Rhynchites auratus is not known to be present in New Zealand. Not recorded in PPIN (2008). No members of the Attelabidae occur in New Zealand (Klimaszewski and Watt, 1997; Kuschel, 2003).

Biology

The adults of *Rhynchites auratus* are hairy and shiny reddish in colour (HYPPZ, 2008). Attacks on green cherry fruit cause mottling. Severely damaged fruit drop. Those which attain maturity, are pierced down to the stone (HYPPZ, 2008).

Dezianian (2005) found that the mean length of adults was about 11mm. Length of first instar larvae was 1.0–1.5 mm, and the last instar measured 9.3 mm. In Europe, *R. auratus* has a two-year life-cycle. The adults appear during bud-burst, and attack the buds, blossoms, shoots and leaves of many fruit trees, with cherry being most severely injured (Thiem, 1938). The adults feed on cherry and sweet cherry (Korchagin, 1987). Adult females have a life span of about three months and lay eggs (rarely more than 85) from June onwards. The females dig channels or galleries near not yet lignified stones and lay an egg at the bottom of the gallery (HYPPZ, 2008), or oviposit in the still-soft stone (Korchagin, 1987). Females lay a single egg in each fruit (Dezianian, 2005).

The oviposition site is easily recognizable from the outside due to its dark coloration and the marked hollow situated in the middle (HYPPZ, 2008). The larvae feed in the stone and develop within it. Once they have completed their development (16–36 days), they leave the fruit, migrate to the ground and pupate in the soil (HYPPZ, 2008). *R. auratus* hibernates as a last instar larva at a soil depth of 5–10 mm. The larval period lasts 18–20 months, thus each generation of this insect is completed in two years (Dezianian, 2005).

From September onwards, adults ascend fruit trees, where they will overwinter, in crevices or under fragments of loose bark (HYPPZ, 2008).

Hosts

R. auratus feeds on members of the Rosaceae. Recorded hosts include: *Prunus salicina*, *Prunus avium* (Arkhangel'skii, 1928; CPC, 2007); *Prunus armeniaca* (Wang et al, 1998); *Prunus spinosa* (Arkhangel'skii, 1928; HYPPZ, 2008); *Pyrus* sp. (Bashkatova et al, 1983).

Plant parts affected

Fruit, leaves (Dezianian, 2005); buds, blossoms, shoots, leaves (Thiem, 1938); flower, fruit and seed (Yang et al, 2005).

Geographical distribution

Asia: China (Yang et al, 2005); Iran (Dezianian, 2005); Kazakhstan (Khairushev, 1970); Turkey (Ozbek et al, 1996). **Europe:** Former USSR, Italy (CPC, 2007).
In China, *R. auratus* has been recorded in Hebei (Wang et al, 1998) and Xinjiang (Yang et al, 2005).

Hazard identification conclusion

Rhynchites auratus is present in China, and is not known to be present in New Zealand. It has been recorded on *Pyrus*, it is associated with fruit and is considered a potential hazard on the *Pyrus* fruit from China pathway.

6.2.2 Risk assessment

Entry assessment

R. auratus damages the buds, young shoots and leaves of cherries, sloe, plums and pears (Arkhangel'skii, 1928). In southern Russia, central Asia and south-western Siberia, it has been observed feeding on the young fruit of a variety of plants including pears. Schreiner (1914) states that although it is usually said that the insects oviposit exclusively on cherries, the author observed females laying eggs in apples, pears, apricots, sloes and less frequently in plums. This is the only reference found for an association between *R. auratus* and pear fruit, but there is a further report that *R. auratus* frequently damages apples in Kazakhstan. When fruiting of cherry is poor, large numbers of weevils migrate to adjacent apple trees damaging up to 60% of the apples on some of them. The adults make openings in the apple fruit and lay eggs directly in the apple (Khairushev, 1970). Collectively this evidence suggests that infestation of pear fruit may not be a regular occurrence. It is assumed that the effect of attacks on pear fruit would be similar to those on cherry fruit, that is, they become discoloured or fall to the ground.

Given that:

- there is very limited evidence for an association between *R. auratus* and pear fruit;
- any infested fruit are likely to be discoloured or fall to the ground and therefore will not be harvested;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Rhynchites auratus* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for R. auratus is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *Rhynchites auratus* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

There is very little information on the association between *R. auratus* and the fruit of *Pyrus*. Only one reference was found, dating from 1914.

6.3 *Rhynchites heros – Japanese pear weevil*

Scientific name:	*Rhynchites heros* Roelofs, 1874 (Coleoptera: Attelabidae)
Other relevant scientific names:	*Rhynchites coreanus* Kono, 1926; *Rhynchites foveipennis* Fairmaire, 1888; *Rhynchites koreanus* Kono, 1926
Common names:	peach curculio, Japanese pear weevil

6.3.1 Hazard identification

New Zealand status

Rhynchites heros is not known to be present in New Zealand. Not recorded in PPIN (2008). No members of the Attelabidae occur in New Zealand (Klimaszewski and Watt, 1997; Kuschel, 2003).

Biology

R. heros has one generation per year. Adults and larvae feed on fruit causing considerable damage (Tseng and Ho, 1937). It oviposits in pears and then partly severs the stalk of the fruit, causing it to drop prematurely. It overwinters in the adult stage (in the pupal cocoon) or occasionally in the larval stage. In Sichuan province, the adults emerge in April and the oviposition period of about 50 days begins in late May. Adults feed on fruit. The female lays about 36 eggs deep within the fruit and seals the aperture with a wax like secretion. The eggs hatch in 6–7 days. The larval period of about 18 days is passed within the fruit. After oviposition the adult cuts the fruit stalk. The affected fruit usually falls from the tree in about seven days, but may remain hanging on the tree for some time, although it gradually shrinks during this period. The adults dies in late June or July. Following fruit fall, the pre-pupal and pupal stages occupy about 80 and 28 days, respectively, and are passed in a cocoon in the soil (Tseng and Ho, 1937).

In Japan, the adults become active in spring when the temperature rises above 10°C, appearing in numbers in April and May and pairing some 20 days later. Oviposition begins about two weeks after pairing and continues until late June. The female lays 83 eggs on average and dies about a week after ceasing to oviposit. The eggs hatch in six days, and the larvae, which mature in about three weeks, pupate in the soil. The pupal stage lasts 3–4 weeks, but the beetles remain underground until the spring, when they feed on the buds. A few larvae do not pupate till the autumn of the year after they enter the soil (Katsumata, 1934).

In Korea, the adults appear about the middle of June. Mating takes place 3–4 days after emergence, and oviposition two days later. About 35–50 eggs are produced by each female and the eggs hatch in a week. The larvae leave the fallen fruit, enter the ground and feed on the young roots of weeds and decayed vegetables; they pupate in May, with the pupal stage lasting 7–9 days (Muramatsu, 1925).

Hosts

Rosaceae: *Pyrus* sp. (Tseng and Ho, 1937; NARB, 1938; Yago, 1933); *Pyrus pyrifolia*, *Pyrus* sp. nr. *communis* and *Pyrus bretschneideri* (AQSIQ, 2007). This document lists the organism as *Rhynchites coreinus* which is assumed to be the same as *Rhynchites coreanus*, which is a synonym for *R. heros*; *Prunus persica* (Yu, 1936); apple, pear, peach, plum, loquat (*Eriobotrya japonica*) and other fruit (Katsumata, 1934).

Plant parts affected

Fruit of pear (Tseng and Ho, 1937; NARB, 1938); fruit (Katsumata, 1934).

Geographical distribution

Asia: China (Tseng and Ho, 1937; Yu, 1936); Japan (Yago, 1933; Muramatsu, 1925; Katsumata, 1934); Korea (Muramatsu, 1925). Within China, it is reported from: Heilongjiang, Jilin, Liaoning, Inner Mongolia, Hebei, Shanxi, Shandong, Shaanxi, Henan, Ningxia, Hubei, Jiangsu, Jiangxi, Zhejiang, Fujian, Guangdong, Hunan, Guizhou, Sichuan, Yunnan (Hua, 2000) and along the coast and into western China (Tseng and Ho, 1937).

Hazard identification conclusion

Rhynchites heros is present in China, and is not known to be present in New Zealand. It has been recorded on *Pyrus* and is associated with the fruit of pears. It is considered a potential hazard on fresh *Pyrus* fruit from China.

6.3.2 Risk assessment

Entry assessment

AQSIQ (2007) reports *Rhynchites coreinus* as a frequent pest on *Pyrus bretschneideri* and *Pyrus pyrifolia.* It oviposits in pears and then partly severs the stalk of the fruit, causing the fruit to drop prematurely. Based on life history information in Sichuan province, oviposition would be complete by the end of July, and the larval stage lasts about three weeks. Therefore, even if the fruit does not drop to the ground immediately, it is extremely unlikely that eggs or larvae would be present in the fruit at the time of harvest (late September onwards for *P. pyrifolia* and *P. bretschneideri* and late August to middle of September for *P.* sp. nr. *communis*). Pre-pupal and pupal stages are not associated with fruit. Adults die in late June or July and the next generation do not emerge from the pupal cocoon until the following spring. In the unlikely event that infested fruit are present on the tree at harvest, partial severing of the stalk is likely to mean that the fruit would be shrivelled and would not be harvested.

Given that:

- eggs and larvae are not likely to be present in fruit at harvest;
- any fruit infested with larvae will fall off the tree or be shrivelled;
- adults die prior to the harvest season;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Rhynchites heros* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for R. heros is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *Rhynchites heros* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

Biosecurity Australia (2008) has given *Rhynchites coreanus* and *R. foveipennis* as synonyms of *Rhynchites heros*. There is little information on either of these names and although we have followed this taxonomy, there is some uncertainty around this.

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7 *Risk analysis of potential hazard organisms: Insecta: Diptera*

7.1 *Bactrocera dorsalis – Oriental fruit fly*

Scientific name: *Bactrocera dorsalis* (Hendel, 1912)

Other relevant scientific names: *Bactrocera conformis* Doleschall, 1858; *Bactrocera ferrugineus* (Fabricius); *Chaetodacus dorsalis* (Hendel); *Chaetodacus ferrugineus dorsalis* (Hendel); *Chaetodacus ferrugineus* Fabricius; *Chaetodacus ferrugineus okinawanus* Shiraki, 1933; *Chaetodacus ferrugineus* var. *versicolor* Bezzi, 1916; *Dacus dorsalis* Hendel, 1912; *Dacus ferrugineus* (Fabricius); *Dacus ferrugineus dorsalis* Hendel; *Dacus ferrugineus okinawanus* (Shiraki); *Dacus ferrugineus* var. *dorsalis* (Fabricius); *Dacus ferrugineus* var. *mangiferae* Cotes, 1893; *Musca ferruginea* Fabricius, 1794; *Strumeta dorsalis* (Hendel); *Strumeta ferrugineus* (Fabricius)

Common names: Oriental fruit fly, mango fruit fly

7.1.1 Hazard identification

New Zealand status

Bactrocera dorsalis is not known to be present in New Zealand. Not recorded in: MAF (1999), Charles (1998), PPIN (2008).

Biology

Oriental fruit fly, *Bactrocera dorsalis* (*sensu stricto*) is part of a species complex (the *B.* (*B.*) *dorsalis* complex) within the subgenus *Bactrocera*. Drew (1991) noted evidence of a number of closely related species infesting commercial fruit in south-east Asia, and Drew and Hancock (1994) recognised and redescribed *Bactrocera dorsalis* (*sensu stricto*) along with another 52 species in this complex from the Asian region. Information on *B. dorsalis* in the western and southern parts of its geographic range may be unreliable because of misidentifications (White and Elson-Harris, 1992), as may be information from the Asian region prior to 1994.

B. dorsalis is an important pest species on *Pyrus pyrifolia* in Punjab, India (Mann, 1997). Adult females lay eggs in the soft skin of ripening fruit. On hatching, the larvae bore into the fruit further and feed on soft pulp. The affected fruit become malformed and, in conjugation with bacterial activity, fruit rot and ultimately fall from the plant (Tara et al, 2006).

Reproduction is biparental with a lek mating system (Shelly, 2001) and the sex ratio is approximately 1:1 (Binay and Agarwal, 2005; Shimada et al, 1979). Pupation occurs in the soil under the host plant, with larvae jumping up to 70 cm to search for available sites (Chu and Chen, 1985). Five generations were recorded per year in Yunnan, in south-western China (Shen et al, 1997). Females have been recorded ovipositing up to 132 eggs in guava, attracted by the wounds in the fruit caused by mechanical injury (Yuan et al, 2005), but egg numbers deposited can vary from 1–132 (Yuan et al, 2005; Chua, 1994).

Female territoriality accounts in some part for oviposition success with larger females tending to defend oviposition sites better (Shelly, 1999).

Emerging adults need to feed on nectar and protein to mature and reproduce, and like Bactrocera tryoni, it is thought the main protein source is from ‘fruit fly-type’ bacteria that adults culture on leaf surfaces. Laboratory studies in Bangladesh found that larval diets without protein sources significantly lowered the weight of resulting pupae (Mahfuza et al, 1999).

Duration of each life stage is dependant on environmental factors, with estimates for egg, larval, pupal and male and female adult longevity between 3.3–6.76, 8.29–92, 6.07–41, 51 days, 73–123 respectively and total life span ranging from 48.43–123 days (Binay and Agarwal, 2005; Vargas and Carey, 1990; Liu and Lee, 1986; Liu et al, 1985; Ibrahim and Gudom, 1978). In laboratory observations of fruit fly on grapes in Taiwan it took 11.7 days for eggs to hatch, complete larval development and pupate (Chu and Tung, 1996).

Studies in China on the influence of temperature on the development of B. dorsalis found that the development of pre-adults ranged from 30.4 days at 19°C to 17.4 days at 36°C. Females laid the most eggs at 22°C (1581 eggs) and the fewest at 36°C (nine eggs). The population doubled in 7.3 days at 34°C and doubled at a much slower rate of 130.7 days at 36°C (Yang et al, 1994). In India, populations of B. dorsalis were highest when the temperature was between 25 and 38°C (Agarwal et al, 1995). The number of generations per year depends on the temperature.

In the south western region of Kunming (Yunnan, China) field observations revealed B. dorsalis could withstand 13°C as a daily temperature average but no flies were recorded in any of the four study years at a daily temperature colder than 10°C (Ye and Liu, 2005). The fly only occurs seasonally, and the area is re-colonised each year by migrating flies from several southern regions (Shi et al, 2005). Shi and others (2005) suggest that because of haplotype similarities found in populations of B. dorsalis in Yunnan Province, separated by >300km, the fly might be engaging in long range dispersal, probably taking advantage of prevailing air currents.

B. dorsalis is a strong flier and is highly mobile. In studies on foraging behaviour B. dorsalis was recorded moving up to 600 m between areas of food and non-food plants in field experiments in Taiwan (Chiu, 1983), where observations showed that bamboo stands were the most preferred sites for resting.

Hosts

Bactrocera dorsalis attacks over 300 cultivated and wild fruit (Mau and Matin, 1992). Host records in Taiwan vary from 89 hosts in 32 plant families, to 150 plants in 38 families (Cheng and Lee, 1991; Cheng and Lee,1993).

Aegle marmelos (golden apple), *Anacardium occidentale* (cashew nut), *Annona reticulata* (bullock’s heart), *Annona squamosa* (sugarapple), *Areca catechu* (betelnut palm), *Artocarpus altilis* (breadfruit), *Artocarpus heterophyllus* (jackfruit), *Averrhoa carambola* (carambola), *Capsicum annuum* (bell pepper), *Carica papaya* (papaw), *Chrysophyllum cainito* (caimito), *Citrus* spp., *Coffea arabica* (arabica coffee), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Dimocarpus longan* (longan tree), *Diospyros kaki* (persimmon), *Ficus racemosa* (cluster tree), *Flacourtia indica*, *Litchi chinensis*, *Malpighia glabra* (acerola), *Malus domestica* (apple) (CPC, 2007), *Mangifera foetida* (bachang), *Mangifera indica* (mango), *Manilkara zapota* (sapodilla), *Mimusops elengi* (spanish cherry), *Momordica charantia* (bitter gourd), *Muntingia calabura* (Jamaica cherry), *Musa* (banana), *Nephelium lappaceum* (rambutan), *Persea americana* (avocado), *Prunus* spp., *Psidium guajava* (guava), *Punica granatum* (pomegranate), *Spondias purpurea*, *Syzygium aqueum* (watery rose-apple), *Syzygium aromaticum* (clove), *Syzygium cumini* (black plum), *Syzygium jambos* (rose apple), *Syzygium malaccense* (malay-apple), *Syzygium samarangense* (water apple), *Terminalia catappa* (Singapore almond), *Ziziphus jujuba* (common jujube), *Ziziphus mauritiana* (jujube) (CPC, 2007); *Pyrus communis* (CPC, 2007; White and Elson-Harris, 1992); *Pyrus pyrifolia* (Mann, 1997).

Plant parts affected

Fruit (Chu and Tung, 1996; Ren et al, 2008; White and Elson-Harris, 1992; Singh and Mann, 2003; Mann, 1997).

Geographical distribution

B. dorsalis was originally described from Taiwan, and occurs in dense populations in Asia and Hawaii. Its distribution includes Pakistan and India to southern Japan, Indonesia to Micronesia, the Mariana Islands and Hawaii (Weems and Heppner, 1999). Recent outbreaks have occurred in California and Florida (Mau and Matin, 1992).

Within China, B. dorsalis occurs in Fujian, Guangdong, Hainan Island, Sichuan, Yunnan, Guangxi, Guizhou and Hunan provinces (Li et al, 2007). A monitoring system for populations of B. dorsalis has been in place in China since 2000. The lures used in the trapping network include Me, Cue, TML and hydrolysed protein with Steiner and McPhail trap types. The following provinces producing apples and pears have been monitored: Anhui, Beijing, Gansu, Hebei, Henan, Liaoning, Shandong, Shanxi, Shaanxi, Tianjin and Xinjiang Autonomous Region. There have been no records of B. dorsalis in any of these provinces since monitoring began (AQSIQ, 2007). Climatic impediments and geographic barriers, among other reasons, prevent flies entering these regions.

Hazard identification conclusion

B. dorsalis is considered a serious fruit pest internationally and has a wide range of hosts, including pears. It is present in China, and absent from New Zealand. It is considered a potential hazard on fresh pears from China.

7.1.2 Risk assessment

Entry assessment

Eggs and larvae are the life-stages of *Bactrocera dorsalis* likely to be associated with pear fruit at harvest. Any eggs would be expected to hatch into larvae during shipment. Larval development takes between 8 and 92 days and longer under cold conditions. A proportion of larvae hatching from eggs shortly before or after harvest would be expected to survive in pears exported to New Zealand. Since the larvae are internal feeders, they are unlikely to be detected during the harvest and packing processes.

B. dorsalis pupates in soil and the adults are mobile and require a protein source to reproduce and would not be expected to remain with fruit after harvest.

B. dorsalis has not been recorded from the main pear growing provinces in China (Xinjiang, Gansu, Shaanxi, Henan, Anhui, Shandong, Hebei, Shanxi, Liaoning and Jilin provinces) as winter temperatures are too cold. However, it may be introduced to these regions through human assisted movement of infested produce from more southerly regions where it is present. *B. dorsalis* would be expected to establish summer populations within the pear growing provinces. There are quarantine measures in place to regulate the commercial movement of infested material within China (AQSIQ, 2007). However these do not appear to apply to the movement of fresh fruit by travellers. The fact that no *B. dorsalis* has been detected in surveillance programmes in the main pear growing provinces suggests that its prevalence in these areas is very low.

Given that:

- eggs and larvae are likely to be associated with fruit at harvest;
- these life stages occur inside the fruit and are unlikely to be detected at harvest;
- a proportion of larvae are expected to survive shipment to New Zealand; but
- *B. dorsalis* has not been recorded from the main pear growing provinces in China, and prevalence in the orchards is likely to be very low;

The likelihood of entry is considered to be very low but non-negligible.

Exposure assessment

Any larvae entering New Zealand in imported pears will have to mature, exit the fruit, and pupate in the ground. Adults emerging from pupation can fly and would readily find a suitable host.

Damaged fruit or uneaten peel disposed of in New Zealand provides an exposure route for *B. dorsalis* entering on imported pears. Infested fruit must remain in a suitable condition long enough for larvae to develop to maturity. The likelihood of finding a pupation site depends on the method of fruit disposal.

Hosts commonly occurring in New Zealand in commercial and backyard situations include: apple, apricot, avocado, banana, capsicum, citrus, fig, grape, guava, mango, passionfruit, pawpaw, peach, pear, persimmon, plum, tomato, grape. There would be no shortage of host plants available all year round.

Given that:

- larvae in infested fruit would need to find a suitable pupation site;
- host plants occur widely, both in commercial and domestic situations;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

Eggs or larvae entering the country will have to mature to adulthood. Females deposit batches of 1–20 eggs in many oviposition stings of a single fruit (Vargas et al.1984). This indicates infected fruit can have both male and female present. Adults need to locate an adult of the opposite sex to be able to reproduce. Adult longevity and the lek mating system are likely to enhance the likelihood of adult flies finding a mate.

New Zealand regions most at risk from the establishment of permanent populations would be those where mean temperatures do not fall below 10°C. The adults are able to survive low temperatures, with a normal torpor threshold of 7°C, dropping as low as 2°C in winter (Smith et al, 1997).

Parts of New Zealand where mean temperatures do not fall below 12°C are most likely to be suitable for the establishment of B. dorsalis. CLIMEX modelling indicates that persistent populations could establish in much of the low-lying areas of New Zealand's North Island and permanent populations could establish in Northland, Auckland, Waikato and coastal areas as far south as Foxton. Current climate conditions are projected to be unsuitable for its establishment in the South Island (Kriticos et al, 2007). The presence of fruit for oviposition may be a limiting factor for the establishment of *B. dorsalis* entering in fruit in early spring.

Once established in the northern part of the country, seasonal re-establishment in other parts of the country during warmer months would be likely, since *B. dorsalis* is a strong flier and is highly mobile. It would also be expected to be transported around the country in infested produce.

Given that:

- reproduction is sexual, but multiple larvae in fruit, adult longevity and lek mating system will increase the likelihood of finding a mate;
- CLIMEX modelling indicates that persistent populations could establish in some parts of New Zealand;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence Assessment

Economic

B. dorsalis is widely recognised as a serious pest and detection of a fruit fly in New Zealand's surveillance programme would need to be reported internationally and might be expected to result in reduced market access for New Zealand host material to markets free from *B. dorsalis*. Given the importance of New Zealand's export industry this would have significant consequences. There may also be adverse effects on market access if the pipfruit industry has to change from its current low chemical production regime.

Fruit infested with *B. dorsalis* become malformed and, in conjugation with bacterial activity, fruit rot and ultimately fall from the plant (Tara et al, 2006). The citrus and avocado industries are likely to be particularly impacted (Kritikos et al, 2007). The reduction in harvest for infested crops would be significant.
The potential economic impacts are considered to be high.

Environment

Overseas *B. dorsalis* attacked *Syzygium* species (Ranganath et al, 1994). The native tree species *Syzygium maire* could potentially become an alternative host for the fruit fly if it established near native lowland forest in which the tree species predominantly occurs. The *B. dorsalis* complex has been recorded from *Solanum.* Although this is a large genus, Beever and others (2007) identified the complex as a potential threat to New Zealand

poroporo (*S. aviculare* and *S. laciniatum*). The likelihood of it establishing on native hosts is less than the likelihood of it infesting fruit and vegetable crops, or orchards.
The potential environmental impacts are uncertain but considered to be low to moderate.

Human health

Bactrocera dorsalis is a common causative agent of pseudomyiasis in humans in Pakistan. *B. dorsalis* recorded from human stools was one of the main causative agents of pseudomyiasis in Pakistan (Khan and Khan, 1987). The link between the fruit fly and this human health issue has not been proven unequivocally, therefore, it is considered a low potential theoretical risk. It is unlikely the conditions required to facilitate this health risk would be found in New Zealand. These include farm or domesticated animals in close proximity to human living areas and low levels of hygiene
The potential human health impacts are considered to be negligible.

Risk estimation

Bactrocera dorsalis has a very low likelihood of entry, moderate likelihood of exposure and moderate likelihood of establishment in New Zealand. The potential impact within New Zealand is high. *As a result the risk estimate for B. dorsalis is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Uncertainty assessment

The prevalence of *B. dorsalis* in the main pear growing areas of China is uncertain, but assumed to be very low.

7.1.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest Free Area

ISPM 26 provides guidelines for the establishment of pest free areas for Tephritidae of economic importance (ISPM No. 26, 2006).

B. dorsalis has been reported from Hong Kong, Fujian, Guangdong, Hainan, Sichuan, Yunnan, Guangxi, Guizhou, Yunnan and Hunan provinces. AQSIQ (2007) indicates that much of Fujian is a ‘potential distribution area’; a part is an ‘occasional distribution area’ and a small part is a ‘prevalent area’ for *B. dorsalis*. Much of Sichuan falls within the ‘not capable of establishment’ area; a small part is ‘potential distribution area’ and a small part is ‘occasional distribution area’. Much of Hunan falls within the ‘potential distribution area’ and part is ‘not capable of establishment’. CLIMEX modelling of the potential distribution of *B. dorsalis* in China predicts that the ‘most suitable’ areas are in southern China including Guangdong, Hong Kong, Hainan and Guanxi Zhuang Autonomous Region. ‘More suitable’ areas include Yunnan, Sichuan, and parts of Fujian province. Suitability drops in Hunan, Hubei, Jianxi and Zhejiang provinces. ‘Unsuitable’ areas occur north of the Yangzi River (Hou and Zhang, 2005). This supports the distribution status described by AQSIQ (2007).

The main pear growing regions include Xinjiang, Gansu, Shaanxi, Henan, Anhui, Shandong, Hebei, Shanxi, Liaoning and Jilin provinces. Sichuan province borders Gansu and Shaanxi, two provinces where pear is grown. Shaanxi has a continental monsoonal climate, with great difference between the areas north and south of the Qinling range (Peoples Daily, 2008). The Qinling range reaches 3767 m and constitutes a natural border between the dry temperate north and the humid subtropical south. The mountains cover more than 50 000 km² and border the Gansu and Qinghai provinces in the west, expanding into the middle of Henan province in the east (Rost, 1992). It is considered unlikely that fruit flies would be introduced across this land barrier naturally. Human transportation of infected plant materials could introduce *B. dorsalis* to pear regions where it is not currently recorded from. Surveillance trapping for fruit fly has not detected any *B. dorsalis* in the main pear growing regions of China since surveillance began in 2000 (AQSIQ, 2007).

Pest Free Area status may be a viable option.

Cold treatment

Fruit is often subjected to a mandatory cold-sterilisation period to kill life-stages inside fruit. For example, the USA requires cold treatment against *Bactrocera dorsalis* on sand pears of 17 days at 0.99°C and 20 days at 1.38°C (TQAU USDA, 2008).

In experiments, at temperatures of 1°C, all 2nd and 3rd instar larvae of *B. dorsalis* in longan fruit were dead after 13 days. Two replicates of 34 502 and one of 32 219 individuals of 2nd and 3rd instar larvae were tested in total (Liang et al, 1999). In litchi fruit, temperatures of 1°C or less killed all 2nd and 3rd instar larvae of *B. dorsalis* after 12 days (Lin et al, 1987; Su et al, 1993). It is not known how applicable these results are to pears which have a different fruit texture.

Since pears for export are normally kept at 0–1°C (AQSIQ, 2007) and transit times between China and New Zealand are expected to be approximately four weeks, it is assumed that in transit cold treatment is likely to be a feasible option for this commodity shipped by sea. Separate treatment would be needed for air freighted produce. No specific efficacy data for cold treatment of *B. dorsalis* on pears has been found. If the treatment used by the USDA is accepted as being effective against *B. dorsalis* on all three pear species covered by this analysis, cold treatment is likely to be a viable option.

Bagging of fruit

Fruit are bagged up to one month after fruit set (see section 2.2.3 and section 4.4). It is not known whether adults would be able to enter the bag between bag and stalk, given a strong olfactory cue from the fruit. The efficacy of this option is uncertain.

Phytosanitary inspection prior to export

Oviposition puncture sites may be difficult to detect in recently infested fruit. Emerging larvae or adults on the fruit surface may be detected on arrival in New Zealand. By itself this is unlikely to be an effective mitigation option.

7.2 *Contarinia pyrivora* – pear midge

Scientific name:	*Contarinia pyrivora* (Riley, 1886) (Diptera: Cecidomyiidae)
Other relevant scientific names:	*Cecidomyia nigra* Meigen, 1804
Common names:	pear midge, pear gall-midge

7.2.1 Hazard identification

New Zealand status

Contarinia pyrivora is not known to be present in New Zealand. Not recorded in: MacFarlane and others (2000). Genus not recorded in Evenhuis (2007).

Biology

In Germany *Contarinia pyrivora* causes crop losses in organic pears (Pedersen et al, 2002). Eggs are laid in flower buds in spring and larvae bore their way into the fruitlets (Bennett and Kearns, 1946), which grow very fast and become unnaturally round. Once they reach about 2 cm they stop growing and become wrinkled and black, and either fall quickly from the tree or remain on the tree and fall later (Polesny, 1990; Pedersen et al, 2002). The larvae leave the fruit and pupate in autumn in the top few inches of soil. Adult midges emerge in spring (Bennett and Kearns, 1946) and after mating the females lay eggs in buds (Polesny, 1990).

In Guizhou (southern China), *C. pyrivora* has two generations in the year. Eggs are laid on young leaves, which the larvae feed on (Luo et al, 2000).

In central China it has 3–4 generations per year and damages pear buds and leaves. The larvae make cocoons and overwinter in the surface layer of soils or under broken bark. They emerge in late March and early April, and pears are damaged from late April onwards (Li and Qing, 1997).

There is only one generation a year in Shandong, China. The overwintered pupae emerge from the soil in mid-March, the larvae appear in early April, and attack the pre-blooming fruit buds of pears. The attacked flower buds do not open, but instead gradually wither and turn black (Dong et al, 1997).

Hosts

The only recorded hosts are *Pyrus* sp. (Hill, 1987); *Pyrus communis* (CPC, 2007; Maciesiak et al, 2003).

Plant parts affected

Pyrus: flower buds (Maciesiak et al, 2003); fruit (Polesny, 1990; Hill, 1987).

Geographical distribution

Asia: China (CPC, 2007; Deng and Nan, 2001).
Europe: Austria, France, Netherlands, Poland, Switzerland, United Kingdom (CPC, 2007); Denmark (Pedersen et al, 2002).

Within China, *Contarinia pyrivora* has been recorded in Shandong (CPC, 2007); Xinjiang (Deng and Nan, 2001); Guizhou (Luo et al, 2000).

Hazard identification conclusion

Contarinia pyrivora is a pest of *Pyrus* spp. and infests the fruit. It is present in China and is not known to be present in New Zealand. It is considered to be a potential hazard.

7.2.2 Risk assessment

Entry assessment

The larvae of *Contarinia pyrivora* infest leaves and sometimes the buds and young fruitlets of *Pyrus*. Infested fruit drop prematurely. Any infested fruit that remain on the tree are black and shrivelled and would not be harvested.

Given that:

- *C. pyrivora* is not associated with mature pear fruit;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Contarinia pyrivora* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for C. pryrivora is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *Contarinia pyrivora* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a ‘regulated pest’. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

7.3 *Drosophila suzukii - spotted wing drosophila*

Scientific name: *Drosophila suzukii* (Matsumura) [Diptera / Drosophilidae]
Common name/s: spotted wing drosophila, cherry vinegar fly

D. suzukii is a member of the subgenus *Sophora*, species-group *melanogaster* and subgroup *suzukii* (Bock 1980). It may be confused with other species. *D. melanogaster* is often known as the common fruit fly. Flies belonging to the family Tephritidae are also called fruit flies, which can lead to confusion, especially as the latter are economic pests in fruit production.

7.3.1 Hazard identification

New Zealand status

New Zealand status: *Drosophila suzukii* is not known to be present in New Zealand. Not recorded in: (Macfarlane et al, 2000; PPIN, 2009) (both accessed 23/10/2009). *Drosophila melanogaster* is known to be present in New Zealand. Recorded in: (Macfarlane et al 2000; PPIN) (accessed 18/03/2009).

Biology

Drosophila suzukii is one of only two of the 3000 species of *Drosophila* that is a plant pest (USU, 2009). The others feed mainly on over-ripe or fallen fruit. *D. suzukii* is widely distributed in Japan, where it infests cherries and grapes severely, with up to 75% of cherry fruits infested (Kanzawa 1939). *D. suzukii* thrives at cooler temperatures. The damage it causes to fruit provides a mean of entry for fungal and bacterial infections and secondary pests that may contribute to further fruit deterioration (Dreves et al, 2009).

Adults are small, with straw yellow bodies and red eyes. Males have a distinctive black spot on the outer edge of the wing and two darkened bands on the forelegs (ODA, 2009; Dreves et al., 2009). Females lack the wing spots (Dreves et al., 2009) and can only be identified by a trained entomologist (ODA, 2009). The larvae as of most *Drosophila* spp. remain un-described (Manning, 2006). The male body is less than a mm in width, while the female body is slightly bigger (Kawase & Uchino, 2005). The adults and pupae are 2-3mm in length (Dreves et al., 2009).

D. suzuki is a temperate climate species, with adults most active at about 20°C; larvae remain motionless at 5°C and begin to crawl at 10°C (Kanzawa, 1939).

In Japan, *D. suzukii* appears to have about 15 generations a year (Kanzawa,1939). In California, it is predicted to have 3 to 10 generations per year (USU, 2009). The life-cycle is completed in about 21-25 days at a constant temperature of 15 °C and about 9-11 days at 25 °C (Kanzawa 1939). The females begin to oviposit 1-4 days after emergence (Kanzawa 1939) and lay 2-3 eggs per fruit on average. A single female can lay around 350 eggs (USU, 2009; Kanzawa 1939). More than one female can oviposit into a single fruit. As many as 65 adults may emerge from a single cherry (Kanzawa 1939). The oviposition period lasts 10-59 days (Kanzawa 1939). The eggs are laid on warm days from April to November in the fruits, ripe fruits being preferred (Kanzawa 1939).

The egg stage lasted 2-72 hours and was completed in about a day in cherry in May and June (Kanzawa 1939). The larvae mature in about 3-13 days (Kanzawa 1939) and develop inside the fruit (USU, 2009). The pupal stage, which is usually passed in the fruits but sometimes in the soil, lasts 3-15 days (Kanzawa 1939). In Japan, the adults begin to emerge in early April and are most numerous in June-July and again in September-October (Kanzawa 1939). The males live 14-29 days and the females 20-48 days when fed on cherry (Kanzawa 1936). Adults emerging from late September onwards over-winter and sometimes survive until the following July (Kanzawa 1939). They enter hibernation in sheltered places in late November at about 5°C (Kanzawa 1939).

Vector

The vectoring capabilities of *D. suzukii* are unknown. However, *Drosophila* spp. have been implicated as vectors of plant pathogenic fungi and bacteria (EOL, 2009). A major role of *D. melanogaster* in the ecosystem is in vectoring micro-organisms (EOL, 2009).

Hosts

D. suzukii has been reported attacking the following fruits in Oregon: blueberries, wild blackberries, red raspberries, marionberries, cherries, strawberries, plums, peaches, grapes, figs, hardy kiwis, and Asian pears (Dreves *et al.* 2009). ODA (2009) additionally reported it from apple, cane berries and persimmon in the field and tomato in the laboratory.
In Japan, Kanzawa (1939) reported it from cherries, grapes, apples, peach, plum and persimmon and Kanzawa (1936) reported it from wild *Rubus*.

Plant parts affected

D. suzukii is associated with fruit, mostly when in a ripe or over-ripe state.

Geographic distribution

D. suzukii is Asian in origin (China, Korea, Japan, Thailand) and is established in the USA, Canada and Spain (ODA, 2009; OSU, 2009). In the USA it has recently established in California, Florida, Oregon, Washington and it is also present in Hawaii (ODA, 2009).
D. suzukii is present in China (Qian et al., 2006; Wu et al., 2007; Bock et al., 1980; ODA, 2009; USU, 2009).

Hazard identification conclusion

Drosophila suzukii has been reported on pears, and is associated with fruit. It is present in China and is not known to be present in New Zealand. It is therefore considered to be a potential hazard.

The only source found reporting an association between *D. suzukii* and pear fruit is the Oregon State University web site which states that there have been confirmed findings of it in Asian pears. There is insufficient information on which to base a risk assessment and risk management measures are not justified at the current time.

Since *D. suzukii*'s distribution appears to be changing rapidly and the range of fruit it damages appears to be increasing, it is important to keep the status of this organism under review and to revisit this assessment if more information or interception records become available.

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8 Risk analysis of potential hazard organisms: Insecta: Hemiptera

8.1 *Aphanostigma iaksuiense – powdery pear aphid*

Scientific name: *Aphanostigma iaksuiense* (Kishida) (Hemiptera: Phylloxeridae)
Other relevant scientific names: *Cinacium iaksuiense, Aphanostigma iaksuiensis*
Common name: powdery pear aphid

8.1.1 Hazard identification

New Zealand status

Aphanostigma iaksuiense is not known to be present in New Zealand. Not recorded in: Teulon et al (2004), PPIN (2008).

Biology

Aphanostigma iaksuiense is monoecious (doesn't alternate between hosts) and remains in the orchard year round. It can either be holocyclic, or anholocyclic (only reproducing parthenogenically) (Barbagallo et al, 2007), although all other accessed literature refers only to holocyclic forms. No evidence was found that it has flighted forms, and the related *Aphanostigma piri* reportedly does not have winged forms (Leclant, 1963).

In Sichuan Province, China, there are nine generations of *A. iaksuiense* per year on pear trees. Reproduction can be sexual or parthenogenic, therefore eggs do not need to be fertilised to produce offspring. Parthenogenic offspring are female only. For *A. piri*, the last generation of parthenogeniae laying eggs gives rise to males and females which produce the over-wintering eggs (Leclant, 1963). It is assumed that a similar pattern occurs in *A. iaksuiense.* Eggs are mainly laid in cracks of tree trunks and branches (Fang, 1980). Eggs overwinter (Fang, 1980) and nymphs hatch in spring, when flowering commences (Zhang and Zhong, 1983). The nymphs suck on the juice of pears, although they are mainly distributed on the flowers of the pear tree (Zhang and Zhong, 1983). Early instar crawlers are the main dispersal stage. First instar nymphs have been recorded crawling 2–3 cm per minute on pear fruit or glass. They can also be spread by other insects. However other life stages are more immobile and normally do not move even if environmental conditions become adverse (Fang, 1980). Kolesova (1967) reports that the autumn sexual generation of *A. piri* is mobile, but has no mouth parts. After mating, the females of this species lay a single egg each, and many females oviposit in the same location. In this species eggs are laid in cracks in the bark, under moss on the trunk and under the corky remains of peduncles on fruit spurs.

Damage to fruit is centred on the calyx end of the pear fruit (Fang, 1980; Zhang and Zhong, 1983). Pears with a persistant calyx are more frequently damaged than those with a decidious calyx (Fang, 1980). Infestation results in black spots, cracking and rotting of the fruit. *A. iaksuiense* is an important pest of bagged pear fruit, occurring at a frequency of 14–50% (Chen and Wang, 2001). In Sichuan province, Fang (1980) reported that the severity of impacts varied depending on the age of the fruit, the age of the pear tree, and the environmental conditions in which it grows. The proportion of fruit damaged ranged from 1% to 62%. Older fruit on mature trees growing in sheltered conditions were more likely to be damaged. *A. iaksuiense* is sensitive to environmental conditions. Eggs die when exposed to sunlight and adults and nymphs are susceptible to wet and windy conditions (Fang, 1980).

Hosts

Pyrus sp. (Blackman and Eastop, 2000; Chen and Wang, 2001; Fang, 1980; Hua, 2000; Tai et al, 2004; Wang et al, 2007; Yoon and Lee, 1974; Zhang and Zhong, 1983); *Pyrus communis* (Blackman and Eastop, 2000); *Pyrus* sp. nr. *communis* (AQSIQ, 2007); *P. pyrifolia* (Blackman and Eastop, 2000; AQSIQ, 2007); *P. bretschneideri* (AQSIQ, 2007).

Plant parts affected

Fruit, bark (Chen and Wang, 2001).

Geographical distribution

Asia: China (Anhui, Beijing, Hebei, Jiangsu, Liaoning, Sichuan, Shandong, Shanxi, Shaanxi, Henan, Yunnan, Zhejiang Provinces) (Fang, 1980; Hua, 2000; Tai et al, 2004; Zhang and Zhong, 1983); Japan (Kishida, 1924); Korea (Blackman and Eastop, 2000; Yoon and Lee, 1974).

Hazard identification conclusion

Aphanostigma iaksuiense has been recorded on *Pyrus* fruit, and is present in China. It is not known to be present in New Zealand, and is considered to be a potential hazard.

8.1.2 Risk assessment

Entry assessment

The eggs of *Aphanostigma iaksuiense* are laid mainly in cracks in the bark and it is assumed that few will be associated with the pear fruit.

Nymphs and adults feed on pear fruit, and are likely to remain on fruit during harvesting. Adults are 0.7 mm in length, and are greenish-yellow in colour (Zhang and Zhong, 1983). Since they occur predominantly at the calyx end of the fruit they are likely to be difficult to detect during harvest and packing. The associated black spots would be more visible, but may not develop until after harvest. Prevalence in orchards is variable but is likely to be higher in those growing pears with persistent calyces.

The likelihood of *A. iaksuiense* nymphs or adults surviving shipment to New Zealand is uncertain. Late generation adults reportedly lived between 18 and 46 days in Sichuan (Fang, 1980). Aphids (species other than *A. iaksuiense)* are frequently intercepted at the New Zealand border on a range of commodities (MAFBNZ, 2009), which indicates that this type of organism can survive some transit conditions.

Given that:

- there is likely to be a high prevalence of *A. iaksuiense* in some orchards;
- nymphs and adults are difficult to detect in the calyx region of the fruit; and
- these lifestages are likely to be able to complete their development on fruit;

The likelihood of entry is considered to be moderate and therefore non-negligible.

Exposure assessment

Fresh imported *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core, but whole fruit or parts of the fruit are sometimes discarded. Such material could allow some *A. iaksuiense* nymphs or adults to disperse and find a suitable host, especially if fruit is disposed of in home gardens.

Early instar 'crawlers' are the main dispersal stage. The life stage most likely to be associated with imported fruit is late generation nymphs or adults. Whilst adults are not normally mobile, it is assumed that the sexual forms at least have the ability to move to find a mate and a suitable oviposition location. *A. iaksuiense* is not known to have flighted forms, so movement would be limited to short distances by walking or being blown in air currents. Since *A. iaksuiense* is only known to feed on *Pyrus* species, contaminated fruit would have to be disposed of near a *Pyrus* host plant. Pear trees are reasonably common garden trees in New Zealand.

Given that:

- late instar nymphs and adults are not very mobile;
- *A. iaksuiense* has a restricted host range;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

Reproduction can be sexual or asexual. Since there is no requirement for a mate for the production of offspring, a single female of a parthenogenic generation could theoretically found a new population.

A. iaksuiense is currently known only from China, Korea and Japan. Its eco-climatic requirements are not known but it is assumed that climate is unlikely to be a factor preventing establishment in New Zealand. It has nine generations per year in Sichuan, China. Multiple generations are likely to allow a population to build up fairly rapidly.

A. iaksuiense is confined to *Pyrus* species. *Pyrus* is widely cultivated in New Zealand, both in orchards and in backyard gardens. It could be spread to new *Pyrus* populations through movement of infested material.

Given that:

- *A. iaksuiense* can reproduce asexually, has multiple generations a year; and
- is not likely to be limited by climate or availability of hosts in New Zealand;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

A. iaksuiense is only known to attack *Pyrus* and its impact would therefore be limited to the pear industry. Hosts available in New Zealand include *Pyrus communis* and *P. pyrifolia* and its crosses. The size of the New Zealand pear industry (*P. communis*) was 412 ha in 2008 (Pipfruit New Zealand Incorporated, 2008). There is no recent available information on the size of the *P. pyrifolia* industry in New Zealand. In 2002, there were

119 ha of *P. pyrifolia* grown commercially in New Zealand (Statistics New Zealand, 2002). This is likely to have declined in line with the European pear industry, which has more than halved since 2002 (from 965 ha in 2002 to 412 ha in 2008) (Pipfruit New Zealand Incorporated, 2008). The degree of damage caused appears to be variable, depending on the variety, the maturity of the tree and environmental conditions. Damage appears to be greater when fruit are grown in bags, which is not a common practice in New Zealand. No reports have been found of virus transmission by aphids and this is backed up by Barbagallo and others (2007). Whilst the impact for individual pear growers might be high, the potential economic impact to New Zealand is considered to be low.
The potential economic impact is considered to be low.

Environmental consequences

A. iaksuiense is monophagous, only recorded on *Pyrus* species. This genus contains no New Zealand native species.
The potential environmental impact is considered to be negligible.

Human health consequences

There are no known human health consequences.

Risk estimation

Aphanostigma iaksuiense has a moderate likelihood of entry, low likelihood of exposure, and a moderate likelihood of establishment in New Zealand. The potential economic impact within New Zealand is low. *As a result the risk estimate for A. iaksuiense is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

The thermal tolerances of *A. iaksuiense* are not known and its ability to survive transit to New Zealand is uncertain. No evidence was found that *A. iaksuiense* has a winged form. It is assumed that its biology is similar to that of *A. piri* which does not have a winged form but does have a mobile sexual form.

8.1.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

A. iaksuiense has been recorded in Anhui, Beijing, Hebei, Jiangsu, Liaoning, Sichuan, Shandong, Yunnan, Zhejiang Provinces in China and is likely to be widespread. However, pest-free area status may be a viable option for *Pyrus* sp. nr. *communis* pears from Xinjiang if its absence there can verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

In-field management

Chen and Wang (2001) state that using insecticidal sprays prior to bagging could reduce the population of *A. iaksuiense* and thereby reduce the damage of pear fruit from 14–50% to 0.8–8.8%. The uncertainty over the efficacy of this measure means it is unlikely to be a viable option.

Bagging of fruit

Individual bagging of fruit is known to be a factor in infestations of this species on *Pyrus* fruit. Bagging is not considered a viable risk management option.

Phytosanitary inspection prior to export

Aphids are small, and tend to congregate around the calyx where they are more difficult to see. Some nymphs and adults may not be detected by sample inspection, especially if prevalence is low.

Cold treatment

There is no information available on the thermal tolerances of this species. The eggs can overwinter; it is not known if cool-storage at 0–1°C for four weeks would result in an increased mortality of the nymphs or adults.

Ethyl formate fumigation

Ethyl formate is a naturally occurring component in fruit with insecticidal properties that has been used as a fumigant for stored products. Mixed life stages of the melon aphid, *Aphis gossypii* had an LD_{99} of 0.2% at one hour treatment. Bartlett pears tested for one hour at room temperature had a maximum tolerance dose of 3.2%. Doses in excess of this caused skin browning (Mitcham, 2005). The effective dose for treatment against *A. iaksuiense* nymphs is not known, but ethyl formate fumigation appears to be an option that warrants further investigation.

8.2 *Aphis pomi – green apple aphid*

Scientific name: *Aphis pomi* De Geer (Hemiptera: Aphididae)
Common name: green apple aphid

8.2.1 Hazard identification

New Zealand status

There are a number of reports of *Aphis pomi* from New Zealand, most of which appear to be derived from the use of this name for *Aphis spiraecola*. Blackman and Eastop (2000) state "*Aphis spiraecola* is often confused in the literature with *A. pomi,* which is a name used by Cottier (1953) for his account of *A. spiraecola* in New Zealand".

Aphis pomi is not known to be present in New Zealand (C. Till and D. Teulon, pers. comms., 2009; not recorded in Teulon et al, 2004).

Biology

Aphis pomi is primarily known as a pest in commercial apple orchards (Dewar, 2007; CPC, 2007). Feeding by *A. pomi* usually causes severe curling of new foliage, as well as twisted growing terminals (Blackman and Eastop, 1994). It excretes copious amounts of honeydew which drips onto the fruit and is often colonised by a black, sooty fungus which causes russeted areas on the fruit, especially around the stem (Beers et al, 1993).

It is monoecious holocyclic, remaining on apple or other Rosaceae throughout the year. It can only maintain itself on growing shoots. Therefore it does not usually hibernate in older orchards, where fresh growth is unavailable in the autumn (CPC, 2007; Dobrovliansky, 1913). It can, however, survive continuously in tree nurseries, where it lays eggs on young shoots (Evenhuis, 1968).

A. pomi overwinters as an egg, laid chiefly on tender twigs (Baker and Turner, 1916). Up to 500 eggs can be laid on 1 cm of shoot with a diameter of 1 cm, in Lithuania. Oviposition of over-wintering eggs usually begins in early September and lasts until all the leaves have fallen and heavy frosts occurred (Rakauskas and Rupas, 1983).

The number of generations recorded per year ranges from 8–10 in Lithuania (Rakauskas and Rupas, 1983); to 16–17 in the Ukraine (Rafal'skii and Kazanok, 1972), and 9–17 in Virginia, USA (Baker and Turner, 1916). Given the large number of generations the length of each life stage is relatively short. The lifespan of adults of the first generation has been recorded as 10 days in Kishinev (Poltzu, 1932). Nymphs feed for 10 to 20 days (depending on temperature) before they become adults. Both nymphs and adults suck phloem from their hosts and prefer to feed on succulent, young tissue (Beers et al, 1993).

Barbagallo and others (2007) indicate that *A. pomi* does not directly injure fruits and in summer, damage by this aphid is negligible.

Hosts

Apples and *Pyrus* are reported as major hosts (CPC, 2007). Other references stating that *Pyrus* is a host include Blackman and Eastop (2000), and Kuo and others (2001).

Minor hosts include *Chaenomeles* (flowering quinces), *Chaenomeles japonica* (Japanese quince), *Cotoneaster*, *Cotoneaster frigida*, *Cotoneaster pannosa*, *Crataegus* (hawthorns), *Cydonia* (quince), *Malus* spp. (ornamental species apple), *Mespilus* sp. (medlar), *Rosa* spp. (roses), *Sorbus* spp. (rowan), *Spiraea salicifolia* (Bridewort), *Spiraea vanhouttei* (Bridal wreath) (CPC, 2007).

Plant parts affected

Leaves, inflorescence, growing points, fruit (CPC, 2007).

On apples, *A. pomi* usually infests succulent terminal growths, but when infestations are severe will also be found on fruits (University of California, 2009a; Cooley, 1914). It is assumed that it would also occur on fruit of *Pyrus* in similar situations.

Similarly Beers and others (1993) state that high populations early in the year may also feed directly on developing fruits of apples, causing small bumps and red spots to appear at the feeding sites. Aphids feeding on fruit of some apple varieties later in the season can result in small circular red spots, which disappear by harvest.

Geographic distribution

China (Chai, 1998): Liaoning, Shaanxi, Shanxi, Gansu, Ningxia, Xingjiang, Henan, Hebei, Shandong, Jiangsu, Zhejiang, Fuian, Guangdong, Sichuan, Yunan (Hua, 2000).
Many other countries in Asia; many countries in Europe, North America; Bermuda (CPC, 2007).

Hazard identification conclusion

A. pomi has been recorded on *Pyrus* and on the fruit of apples. It is present in China, and is not known to be present in New Zealand, and is considered to be a potential hazard.

8.2.2 Risk assessment

Entry assessment

Aphid populations usually follow a pattern where there is a rapid increase in numbers at the start of the season, then a decrease, followed by a possible second peak (Kindlmann et al, 2007). *Aphis pomi* has a population peak on pear in October in Taiwan (Kuo, 2002). This suggests that numbers in orchards at the time of harvest may be high. *A. pomi* have been recorded as being on apple fruit when numbers are high and it is assumed that they would behave similarly on pears. Therefore some aphids may be present on harvested fruit. However, *A. pomi* stay on Rosaceae hosts throughout the year (they do not migrate in search of alternative hosts) and therefore only occurs in younger orchards, that have fresh growth available until the autumn. Furthermore, Dobrovliansky (1913) states that *A. pomi* occurs less frequently on pears than on apples and that by autumn (harvest time) no aphids were found on the leaves of pear trees.

Succulent terminal growth appears generally to be the preferred feeding site. Both winged and wingless forms are mobile and it is assumed that they would readily move off fruit in search of better feeding areas. Eggs are not known to occur on fruit.

Given that:

- *A. pomi* is only likely to be present in some pear orchards and population levels in pear orchards are likely to be low;
- *A. pomi* appears to only infest fruit when populations are high;
- fruit are not its preferred plant part and no reports have been found of *A. pomi* on pear fruit;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Aphis pomi* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for A. pomi is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *Aphis pomi* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

The association of *A. pomi* with mature *Pyrus* fruit is uncertain.

8.3 *Cacopsylla spp. - pear sucker*

8.3.1 Hazard identification

Scientific names: *Cacopsylla pyricola* Förster, 1848 [Homoptera: Psyllidae]
Psylla chinensis Yang & Li 1981
Psylla betulaefoliae Yang & Li 1981
Psylla heterobetulaefoliae Yang & Li 1981
Psylla pyri Linnaeus
Psylla changli Yang & Li 1981
Psylla phaeocarpae Yang & Li 1981
Psylla liaoli Yang & Li 1981
Psylla jiangli Yang & Li 1981
Psylla qianli Li & Yang 1984
Psylla xanthisma Li & Yang 1984
Psylla kunmingli Li & Yang 1984
Psylla cengshanli Li & Yang 1984
Psylla simaoli Li & Yang 1984
Psylla aili Li & Yang 1984
Psylla xiaguanli Li & Yang 1984
Psylla erhaili Li & Yang 1984
Psylla yunli Li & Yang 1984
Psylla dianli Li & Yang 1984
Psylla chaenomelei Li & Yang 1984
Psylla pyrisuga Förster 1848

Other relevant scientific names: The genus *Cacopsylla* is a common alternative name for species placed in *Psylla* (Hodkinson, 1984). *Cacopsylla* will be used in this assessment.

Common name/s: pear sucker, pear psyllid, pear psylla

New Zealand status: None of these species are known to be present in New Zealand. Not recorded in: CPCI (2008), Charles (1998), PPIN (2008).

Taxonomy

There are many reported species of pear psyllids in China and some confusion over their identity. Hodkinson(1984) reports that taxonomic problems arise because some species are dimorphic with morphologically distinct summer and winter forms. Historical mis-identifications have compounded the difficulties. Yang & Li (1981) identified eight species from eight provinces in northern China, including *Cacopsylla chinensis*, which may previously have been mistakenly recorded as *C. pyrisuga*. *C.chinensis* is one of the major pests of *Pyrus bretschneideri* (Li & Yang, 1984).

Li & Yang (1984) identified 11 species of pear psyllid from the Yunnan and Guizhou provinces in southern China which had previously been known only as pear psyllids. These were all different from the species identified by the same authors in northern China (Yang & Li 1981). It is not known whether these are in fact some of the new species identified by Yang & Li (1981). Buckhardt & Hodkinson (1986) state that some of the species identified by these authors may be synonymous with species in the *C. pyricola* /*C. pyrisuga* group. There has been similar confusion over the taxonomy of the pear psyllids in the western Palaearctic, where Buckhardt & Hodkinson (1986) conclude that despite earlier confusion, *C.pyrisuga* is a clearly defined species and that the *C. pyri* / *C. pyricola* group is a complex of related but distinct species with overlapping geographical regions. *C. chinensis* has been reported as occurring frequently on *Pyrus bretscheideri* and *P. pyrifolia* and also occuring on *P*.sp.nr. *Communis* in China (AQSIQ, 2007). For the purposes of this assessment it is assumed that all the organisms listed above are present on pears in China.

Biology

Given the confusion over the taxonomy, *C. chinensis* has been assessed as a represenative of the group of pear psyllids. *C. pyrisuga* differs biologically from the other species in this group in that it is uni-voltine (Buckhardt & Hodkinson 1986). However, no confirmed records for this species occurring in China have been found.

Pear psyllas are an important pest of pear trees in China (Yang & Li 1981). They are among the most important pests of *Pyrus communis* in Europe, Asia and North America (Buckhardt & Hodkinson 1986). Most of the species are only known from *Pyrus* hosts (Li &Yang 1984, Hodkinson, 1984). Their feeding results in withering of the leaves, flowers and young fruits, stunting of the shoots and the covering of the fruit and trees with sooty mould developing on the excreted honeydew. In the USA, they damage pears in three different ways: spreading a mycoplasma that causes pear decline disease; injecting a toxin into the tree that produces blackening and burning of the foliage known as psylla shock; and by copious production of honeydew which marks fruit and supports the growth of sooty mould. They have shown rapid evolution of resistance to several classes of insecticides (Agusti et al. 2003)

Psyllids resemble tiny cicadas and are only 1-2 mm long. Adults jump and fly when disturbed, but are weak flyers (Hill 1994).

C. chinensis has five generations a year on fragrant pear in Zinjiang province (Jiang et al. 2003). They over-winter at the adult stage, in bark crevices on the host plant, and sometimes in debris on the ground (Jiang et al. 2003). Adults emerge once temperatures exceed 0 °C. Oviposition begins prior to petal fall in pear trees and peaks from mid to late March (Jiang et al. 2003). Over-wintering females lay between 200-300 eggs at the base of leaf and flower buds, on stalks, under leaves and on leaf tips. Newly-hatched nymphs aggregate to form colonies on buds, leaves and stalks (CPCI 2008). Nymphs and adults damage the tree by sucking sap from buds, young shoots and fruit, producing copious amounts of honeydew which promotes fungal growth (Jiang et al. 2003), and by injecting a toxin into the tree which causes blackening and burning of the leaves (CPCI, 2008). Over-wintering females live 180-210 days, whilst summer adults live only 9-27 days. Adult populations peak in late September (Jiang et al. 2003). *C. chinensis* avoids bright light, seeking shady crevices in which to hide (Jiang et al. 2003).

At least some of the pear psyllids vector *Candidatus* Phytoplasma pyri that causes pear decline disease (Blomquist & Kirkpatrick 2002). No record was found of this mycoplasma in China.

There are three records of psyllids intercepted at the New Zealand border on pears: unidentified psyllids on pears from the USA, viability unrecorded; a live male *C. pyricola* on *Pyrus pyrifolia* from South Korea; live gravid female *C. pyricola* on ya pears from China (MAFBNZ Interceptions Database 2009). This demonstrates the ability of psyllids to be transported long distances on pear fruit.

Hosts

Psyllids, including pear psyllids are usually host specific, breeding on a narrow range of host plants usually within a single genus. All except two true host plant records for this group are for the genus *Pyrus*. The exceptions are *C. pyricola* on *Mespilus* sp. and *Cacopsylla* sp. on *Stranvaesia glaucescens*. There is however evidence that adults, particularly of *C. pyrisuga* can shelter on other plants particularly conifers during winter and *C. pyricola* may feed, but not breed on other tree species during the summer (Hodkinson, 1984). The species of pear that are hosts are not always recorded in the literature, but *C. chinensis* has been reported on *P. breschiederi* (Hodkinson, 1984) and *Pyrus* sp. nr. *communis* (Jiang et al. 2003). Hodkinson (1984) reports that most psyllids appear to feed on more than one *Pyrus* species.

Plant part(s) affected

Shoots (Horton *et al.* 2007); shoots, leaves, blossoms (Hill 1987); Some first generation nymphs feed on sepals and calyx ends of fruit (Burts et al. 1993); Buds, shoots and calyx end of fruit (Jiang et al. 2003).

Geographical distribution

C. pryicola is broadly distributed across temperate Europe and Asia Minor. It is believed to have been introduced to North America in 1833 and is now widespread. It has also been reported from Argentina (Hodkinson, 1984). In China it is reported in Xinjiang (Hua, 1998).

C. pyri occurs throughout western Europe as well as in China and eastern Russia (Hodkinson, 1984).

C. pyrisuga occurs in Europe but apparently not in China (Hodkinson, 1984).

The other species are known only from China:
Cacopsylla chinensis: Beijing, Heibei, Shanxi, Nei Mongol, Shaanxi, Ningxia, Liaoning, Shandong (Yang & Li 1981; Hua,1998), Xinjiang (Jiang et al. 2003)
C. betulaefoliae: Heibei, Beijing (Yang & Li 1981), Hebei (Hua,1998)
C. heterobetulaefoliae: Heibei, Beijing (Yang & Li 1981)
C. changli: Heibei (Yang & Li 1981)
C. phaeocarpae: Heibei, Beijing, Shaanxi (Yang & Li 1981)
C. liaoli: Liaoning (Yang & Li 1981)
C. jiangli: Xinjinag (Yang & Li 1981)
C. qianli, C. xanthisma, C.kunmingli, C. cengshanli, C. simaoli, C. aili, C. xiaguanli, C. erhaili, C. yunli, C. dianli, C. chaenomelei: Yunnan and/or Guizhou provinces in Southwest China (Li & Yang 1984).

Hazard identification conclusion

Several *Cacopsylla* spp. including *C. chinensis* have been recorded on *Pyrus* spp. and are present in China. They are not known to be present in New Zealand. Pear psyllids have been intercepted on imported pear fruit and they are considered to be a potential hazard.

8.3.2 Risk assessment

Entry assessment

Whilst *C. chinensis* prefers young shoots, adults and nymphs have been reported feeding at the calyx end of the fruit. They also occur in large numbers in host trees, are mobile, and could be present on pear fruit at harvest, as hitchhikers. Being tiny, and actively seeking shady places to hide, they may not be detected during the harvest and packing processes. Adults present on fruit at harvest will be of the over-wintering generation which are long-lived.

CPCI (2008) indicates that over-wintering adults may be transported together with the pear (or other goods) over long distances. CPCI (2008) indicates there is a risk of introducing the species and phytosanitary measures are recommended. It notes that the risk does not apply to *C. pyrisuga,* presumably because this species does not over-winter on its host plant and since it has only one generation a year, the adults may be expected to leave the orchards prior to harvest.

The interceptions of pear psyllids on ya pears at the New Zealand border provides supporting evidence that they can enter on imported fruit.

Given that:

- some pear psyllids feed on the calyx end of fruit;
- there is likely to be a high prevalence of pear psyllids in some orchards;
- being mobile, psyllids may be present on harvested fruit even though they are not feeding on them;
- nymphs and adults are tiny and difficult to detect and may actively hide in the calyx area;
- adults would be likely to survive transit to New Zealand

The likelihood of entry is considered to be moderate and therefore non-negligible.

Exposure assessment

Fresh imported *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core, but whole fruit or parts of the fruit are sometimes discarded. Such material could allow psyllids to disperse and find a suitable host, especially if fruit is disposed of in home gardens.

Since pear psyllids are only known to feed on *Pyrus* species, contaminated fruit would have to be disposed of near a *Pyrus* host plant. Psyllids can jump and fly, albeit weakly. Pear trees are reasonably common garden trees. It is not known whether *Pyrus communis*, which is grown most commonly in New Zealand, is a suitable host for many of the psyllids associated with the pears for which China is seeking access. If *P. communis* is not a suitable host then the likelihood of exposure would be very low.

Given that pear psyllids:

- are mobile and can fly at least weakly, but
- have a restricted host range, although the extent of restriction within the genus *Pyrus* is not known

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

Many of the pear psyllids have only been recorded from China and from relatively restricted locations. For instance in one survey, none of the species found in the northern part of China were recorded from the southern parts. This may indicate that they have tight eco-climatic and/or host requirements. Conversely, given the confusion over taxonomy they may not be distinct species. Members of the *C. pyricola* group have been reported from diverse localities across the USA, Europe and Asia.

Adult *C. chinensis* over-winter in bark crevices in Xinjiang Province which has hard winters, indicating that they have the ability to withstand adverse climatic conditions. Multiple individuals would need to enter together or multiple infested fruit would need to be disposed of in the same area for reproduction to occur. The large number of eggs produced and multiple generations per year would be expected to allow a population to build up fairly rapidly if appropriate conditions are found.

Given that:

- At least parts of New Zealand are likely to be climatically suitable, and
- Rapid population build is likely to be possible, but
- Multiple individuals would be required to establish a viable population

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences
Pear psyllids are only known to attack *Pyrus* spp. Hosts available in New Zealand include *Pyrus communis* and *P. pyrifolia* and its crosses. The size of the New Zealand pear industry (*Pyrus communis*) was 412 ha in 2008 (Pipfruit New Zealand 2008). There is no recent available information on the size of the nashi industry in New Zealand. In 2002, there were 119 ha of nashis (*Pyrus pyrifolia*) grown commercially in New Zealand (Statistics New Zealand 2002). This is likely to have declined in line with the European pear industry, which has more than halved since 2002 (from 965ha in 2002 to 412 ha in 2008) (Pipfruit New Zealand 2008). The degree of damage would depend on which species of *Pyrus* are hosts. If *Pyrus communis* is a suitable host the consequences would be expeced to be larger than if *P. pyrifolia* and some ornamental *Pyrus* species are the only affected species. If pear decline is present in China, the impacts would be expected to be higher.
Whilst the impact for individual pear growers would be expected to be high, the potential economic impact to New Zealand is uncertain but considered to be low

Environmental consequences
Pear psyllids are only recorded on *Pyrus* species. This genus contains no New Zealand native species.
The potential environmental impact is considered to be negligible.

Human health consequences
There are no known human health consequences.

Risk estimation

Pear psyllids have a moderate likelihood of entry, a moderate likelihood of exposure and a low likelihood of establishment in New Zealand. The potential economic impact within New Zealand is expected to be low. *As a result the risk estimate for* pear psyllids *is non-negligible and they are classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

Although it is clear that at least *C. chinensis* is present on *Pyrus bretschneideri* in China, there is considerable uncertainty about the taxonomy of the pear psyllids, and which additional species are present in China and which species of pear are their hosts.
There is also uncertainty about the frequency of association with pear fruit.

8.3.3 Risk management

Options:

A subset of the risk management options identified in chapter 4 that are relevant to this organism are listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

Pear psyllids are widespread. Given the taxonomic difficulties it is unlikely that pest-free area status will be a viable option.

Bagging of fruit

Given the small size of pear psyllids it is likely that they could enter between the bag and the pear stalk. However, bagging is likely to reduce the likelihood of accidental association by adults landing on fruit at harvest time.

Airbrushing

High pressure air brushing is expected to remove psyllids, except perhaps any within the calyx of the fruit.

Phytosanitary inspection prior to export

Pear psyllids are tiny and difficult to see. They may not be detected by sample inspection, especially if prevalence is low.

Cold treatment

There is no information available on the thermal tolerances of this group. However, since adults over-winter cold treatment is not likely to be a viable option.

A combination of fruit bagging, high pressure air blasting and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

8.4 *Chrysomphalus dictyospermi – Spanish red scale*

Scientific name: *Chrysomphalus dictyospermi* (Morgan, 1889) (Hemiptera: Diaspididae)

Other relevant scientific names: *Aspidiotus agrumincola* De Gregorio, 1915; *Aspidiotus dictyospermi arecae* Newstead, 1893; *Aspidiotus dictyospermi jamaicensis* Cockerell, 1894; *Aspidiotus dictyospermi* Morgan, 1889; *Aspidiotus mangiferae* Cockerell, 1893; *Chrysomphalus castigatus* Mamet, 1936; *Chrysomphalus dictyospermatis* Lindinger, 1949; *Chrysomphalus dictyospermi agrumicola* De Gregorio, 1915; *Chrysomphalus minor* Berlese, 1896 (ScaleNet, 2009)

Common names: Dictyospermum scale, Spanish red scale, Morgan's scale, palm scale, western red scale.

8.4.1 Hazard identification

New Zealand status

Chrysomphalus dictyospermi is not known to be present in New Zealand. Not recorded in Charles and Henderson (2002). Recorded as absent from New Zealand in PPIN (2008).

Biology

The scale cover of the adult female is rather thin, nearly circular, but sometimes irregular in outline; flat; 1.5–2.0 mm diameter; greyish or reddish-brown, often with a coppery tinge; with a distinctly raised ring in the centre; and exuviae more or less central, yellow or white (AEI, 2008).

Reproduction is sexual, and continuous in tropical conditions. However, both uniparental as well as biparental populations occur in the USA. The female which lives for several months, lays 1–200 eggs under her scale cover (Chkhaidze and Yasnosh, 2001). The first-instar crawlers are the primary dispersal stage and disperse by wind or animal contact or crawling. The nymphs look for a place to feed, becoming static when they find a suitable site. Crawlers develop for 10–15 days before the first moult, with the entire life-cycle completed in 91 days at 18ºC and 71 days at 25 ºC (Cabido-Garcia, 1949). In California, *C. dictyospermi* has three or four overlapping generations each year; in Egypt, only two (AEI, 2008); in Turkey, there are three to six generations, overwintering as first or second-instar nymphs; in the republic of Georgia two or three generations and no winter diapause; in Italy, the species overwinters mainly as young adult females. *C. dictyospermi* multiplies much more slowly in cold weather than in tropical conditions (CPC, 2007). Experiments conducted in Portugal (Cabido-Garcia, 1949) determined the threshold temperature for development of the species was at 5.8 ºC. It is thought that females are more resistant to low temperatures (Chkhaidze, 1984).

There are two immature, feeding stages in the female and four immature stages in the male; the last two of which (pre-pupa and pupa) are non-feeding and are spent beneath the scale cover secreted by the second-instar male. After moulting to adult, the male spends some time sitting beneath this scale while his flight muscles mature, before flying away to seek females (CPC, 2007).

The adult male cannot feed and is very short-lived. The adult female lives for several months and feeds throughout her life. Mortality due to abiotic factors is high; in winter, it may reach 78% in the Republic of Georgia, and 40% in Turkey (CPC, 2007).

Hosts

C. dictyospermi is highly polyphagous. AEI (2008) notes that it is recorded from hosts belonging to 73 plant families. A combined host list from AEI (2008), CPC (2007) and ScaleNet (2009) includes 234 species, 226 genera and at least 95 families. Hosts include woody trees and shrubs and monocotyledons such as irises. Favoured hosts are palms, *Dracaena* and *Citrus* species (AEI, 2008).

The hosts most significantly damaged by *C. dictyospermi* vary from place to place. It is known mainly as a serious pest of *Citrus* (AEI, 2008) and is recorded as such in the Western Mediterranean Basin, Greece and Iran (ScaleNet, 2009) and countries in the South Pacific Region, Black Sea region of Russia. It is a pest of olive in Italy, Spain and Turkey (AEI, 2008). In Russia, it is a pest of tea (CPC, 2007). In Turkey, *C. dictyospermi* has in the past been most active in citrus plantations in the Aegean region. Damage is generally caused by the larvae and is not economically serious. It is economically important in France (AEI, 2008). It is also important on several hosts in Brazil, and is regarded as a pest in Argentina, where it occurs on both cultivated and native plants; in Chile it is a primary pest on *Citrus* and is common on ornamental plants. It is a minor pest in Mexico, South America and the Republic of Georgia (ScaleNet, 2009) but CPC (2007) states that in the Republic of Georgia, it is the main scale insect pest of citrus. It is regarded as a dangerous pest in the Palaearctic region and Florida (AEI, 2008). In Egypt, it attacks ornamental plants under glass. It is also very destructive to roses and has been recorded attacking *Pinus caribaea* and *Pinus caribaea* var. *hondurensis* in Fiji (CPC, 2007).

Pyrus communis (ScaleNet, 2009); *Pyrus* spp. (CPC, 2007; AEI, 2008). CPC (2007) lists *Pyrus* as a minor host.

Plant parts affected

C. dictyospermi generally prefers leaves, but is sometimes found on fruit and occasionally on branches (AEI, 2008).

Geographical distribution

C. dictyospermi is widespread and present in Europe and, Africa, North, Central and South America, Asia and the Pacific Islands.

Chrysomphalus dictyospermi is probably native to southern China (CPC, 2007). It is widely distributed in subtropical regions of the world and also present in tropical regions and under glass in temperate areas (AEI, 2008). It is distributed predominantly in Mediterranean countries such as Turkey and Syria, and in Middle Eastern countries such as Iran. It has a wide distribution in the South Pacific area on numerous plant species, usually on the leaves. Interceptions at quarantine stations from the area, on citrus and *Howeia forsteriana*, suggest that it has an even wider distribution in the Pacific region (CPC, 2007). It is also widely distributed in Africa, South Asia, southern Europe the USA, Central and South America (AEI, 2008; CPC, 2007; ScaleNet, 2009)

C. dictyospermi is present in China in Fujian, Guangdong, Henan, Hong Kong, Hubei, Hunan , Shaanxi, Hebei, Shanxi, Jiangsu, Jianxi, Zhejiang, Hainan Guangxi, sichuan, Yunan and Shandong (Hua, 2000; AEI, 2008).

Hazard identification conclusion

Chrysomphalus dictyospermi is a pest of *Pyrus communis* and other *Pyrus* species. No record of its presence on *Pyrus* fruit was found but it is recorded on fruit of other plants, notably *Citrus,* and is recognised as being transported on the fruit of its hosts in trade (CPC, 2007). It is present in China, is not present in New Zealand, and is considered to be a potential hazard.

8.4.2 Risk assessment

Entry assessment

C. dictyospermi is likely to be widespread in China. The likelihood of it being present on pear fruit is low as *Pyrus* is not a major host and fruit is not the preferred plant part. Either crawlers or adult females could be present, depending on the population dynamics at the orchard. Both these life stages are small (less than 2 mm diameter), and might not be detected during the pre-export process. A journey time of about four weeks is unlikely to be a barrier to survival and a gravid female could lay eggs during shipment.

Given that:

- early instar nymphs and/or adult females could be present on pear fruit;
- nymphs and adults are not easy to detect and likely to survive transfer to New Zealand; but
- *Pyrus* is not a major host and fruit is not the preferred plant part;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Fresh imported *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core, but whole fruit or parts of the fruit are sometimes discarded. Such material provides an exposure route for *C. dictyospermi* entering on imported pears. Gravid females would need to be present on fruit and the infected fruit would need to be in close contact with a suitable host so that hatching crawlers could crawl or be blown to the host. The passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. Crawlers are susceptible to extremes of temperature, desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage (APHIS, 2007).

The very wide host range of *C. dictyospermi* increases the likelihood of any nearby tree being a suitable host. Plants attacked overseas which occur in New Zealand include: citrus, olives, avocado, roses, aubergine, *Acacia*, *Eucalyptus*, *Euphorbia*, *Ficus*, macadamia, passiflora, *Phormium*, pines, *Pittosporum*, *Prunus* sp., guava, pears, oaks, willows, *Sophora*, *Strelitzia* and grapes. A small scale study of the length of time adult females of *Chrysomphalus aonidum* could survive on picked citrus fruit or the peel of citrus, found that the death of full grown females on picked fruits occurred 3–4 weeks after picking. On peels, the adult females survived from 6–17 days (Schweig and Grunberg, 1936). It is less likely that adults would survive long enough to find a new host than nymphs.

Given that:

- crawlers can move short distances actively or long distances passively;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality;
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant;
- adult survival on picked fruit is relatively short;
- *C. dictyospermi* has a wide host range and suitable hosts are widely distributed in New Zealand;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

C. dictyospermi reproduces sexually and at least one individual of each sex would be necessary to establish a viable population. The female lays up to 200 eggs under her scale. The males can fly. These factors will increase the likelihood of finding a mate. There are often multiple generations a year, which increases the rate of population build up.

In Portugal, the lower limit for development of *C. dictyospermi* was about 6 ºC (Cabido-Garcia, 1949). Given that *C. dictyospermi* overwinters in cold climates it is likely to be able to establish in the northern parts of the North Island, on the East Coast or the northern part of the South Island, and elsewhere in protected environments such as greenhouses or glasshouses. There would not be a shortage of suitable hosts. Once established, it would be readily transported around the country on plant material.

Given that:

- *C. dictyospermi* reproduces sexually, but features of its biology increase the likelihood of an individual finding a mate;
- climate is unlikely to be a barrier to establishment in at least some areas;
- multiple generations a year, enable rapid population build up and *C. dictyospermi* can easily be spread in association with transported plant material;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

As *C. dictyospermi* is a significant pest of citrus and has a wide host range on woody plants, it is likely to have economic effects on commercial production of citrus in New Zealand. *C. dictyospermi* causes considerable damage to *Citrus* spp. turning the leaves chlorotic, and drying and killing the branches, and reducing the market price of the fruit (CPC, 2007). It could affect other crops such as pears, olives and cut flowers.
The potential economic impact in New Zealand is considered to be moderate.

Environmental consequences

Its polyphagous nature suggests that it might attack a wide variety of plants in the environment, including the native nikau palm (*Rhopalostylis sapida*), *Phebalium* and *Melicope* (Rutaceae – same family as citrus). There is a record of *C. dictyospermi* on *Metrosideros* (Hoy, 1958) and it is likely that it could affect pohutakawa, an iconic native species in New Zealand. Whilst the long term ecological effects are uncertain, there would be associated social and cultural impacts. Impacts are likely to be restricted to the warmer regions of the country.
The potential environmental impacts are uncertain but considered to be moderate.

Human health consequences

There are no known human health issues for this scale insect.

Risk estimation

The likelihood of *Chrysomphalus dictyospermi* entering New Zealand with *Pyrus* fresh fruit from China is low, the likelihood of exposure is low and the likelihood of establishment is moderate. The potential economic impact within New Zealand is moderate. *As a result the risk estimate for C. dictyospermi is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

No records were found of *C. dictyospermi* on pear fruit, it is assumed, given the biology of the organism and records of it occurring on other type of fruit, that crawlers and adults are likely to occur on fruit either as hitchhikers or directly. Much of the information on its biology is derived from studies on *Citrus*. It is assumed that this will also apply to *C. dictyospermi* on *Pyrus*. The impacts of the scale on native species is uncertain.

8.4.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest-free area

The main pear growing areas for *Pyrus bretschneideri* and *P. pyrifolia* are the provinces/regions of Hebei, Shandong, Shaanxi, Shanxi, Gansu, Liaoning, Jilin, Beijing, Henan, Anhui and, for *P*. sp. nr. *communis*, Xinjiang Autonomous Region.

C. dictyospermi has been recorded from most of these and is likely to be widespread in China. Pest-free areas are not likely to be a viable option for *Pyrus bretschneideri* and *P. pyrifolia* but may be an option for *P*. sp. nr. *communis* from Xinjiang Autonomous Region if its distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

Bagging of fruit

Fruit are bagged up to one month after fruit set (see section 2.2.3 and section 4.4). Crawlers are unlikely to enter the bag between bag and stalk. However, they could access the fruit prior to bagging. Inspection of surrounding leaves and fruit when bags are changed would give prior warning of an infestation. *P*. sp. nr. *communis* fruit are not bagged and this is not a viable option for these fruit.

High pressure air blasting

Use of high pressure air guns in the pack houses would be expected to remove crawlers which are blown in the wind, but adults would be unaffected.

Phytosanitary inspection prior to export

Mature scale insects are up to 2 mm in diameter and may be visible on the fruit. However, they could be missed if few were present.

Cold treatment

Since both larvae and adult females over-winter they are likely to be able to survive refrigerated shipment to New Zealand or other cold treatment.

A combination of fruit bagging, high pressure air blasting and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

8.5 *Dolycoris baccarum – sloe bug*

Scientific name: *Dolycoris baccarum* (Linnaeus, 1758) (Hemiptera: Pentatomidae)
Other relevant scientific names: *Cimex baccarum* Linnæus, 1758, *Mormidea baccarum*; *Pentatoma baccarum*
Common names: berry bug, sloe bug, shield bug

8.5.1 Hazard identification

New Zealand status

Dolycoris baccarum is not known to be present in New Zealand. Not recorded in: Larivière and Larochelle (2004), PPIN (2008).

Biology

In Henan, China, *Dolycoris baccarum* feeds on pear fruit and causes fruit drop or hardening and marking of the skin (Yu et al, 2002). Cage experiments in apple and pear orchards of Norway, found that *D. baccarum* attacked the fruit, but the damage was less severe than that caused by other pests (Soerum, 1977). In Russia, where *D. baccarum* is known as the berry bug, the pest damages leaves of a number of fruit trees, shrubs and forest trees (Sadigov, 1990). *D. baccarum* is a stinkbug, and can generate a smell from the 3^{rd} instar onwards (Chen et al, 1990). Since it can hibernate in buildings it has the potential to be a nuisance pest.

Dolycoris baccarum has three generations per year in Shandong and Henan, China (Dong et al, 2000; Yu et al, 2002). The adults of each generation emerge in late May, mid-July and late August, respectively. The second generation accounts for approximately 77% of total numbers (Dong et al, 2000). On pear trees, adults begin to attack young leaves and shoots, and to lay eggs in mid-April (Yu et al, 2002). Further north, in Jilin Province, there are only one to two generations per year (Yi, 1997).

D. baccarum over-winters as an adult from early November (Yu et al, 2002) and can tolerate extremely low temperatures; freezing and super freezing points (lethal temperature) are -5.2 and -8.5°C, respectively (Dong et al, 2000). Adults are 9 to 12 mm long (Yu et al, 2002). They hibernate in gaps of buildings, on or in walls, and in dead leaves on the ground (Yu et al, 2002). In wheat fields in Shandong, they over-winter in the fields, sometimes on the stalks of the wheat, and can tolerate cold winters (for example ground temperature -17oC) by finding crevices, by staying beside warm buildings or under leaves and bark where the temperature does not get as low (Dong et al, 2000).

In southern Norway, eggs are laid in masses of on average 23 eggs on leaves of strawberry, raspberry and lily-of-the-valley, leaves and stalks of tomato and flowers of marguerite (Conradi-Larsen and Soemme, 1973). On tobacco plants, individual eggs are about 1 mm high and are laid in masses of on average 14 +/- 8 on leaves, and tops of stems of the tobacco plants (Chen et al, 1990). Yi (1997) recorded twenty to thirty eggs per egg mass also on tobacco. No reports have been found of egg laying on the fruit of Pyrus. In Norway, eggs had a 60% hatch rate (Conradi-Larsen and Soemme, 1973). Under laboratory conditions at 30ºC, egg development takes 26 days.

Adults and nymphs feed on pear fruit. Damage to very young fruit causes them to fall. Feeding on more mature fruit results in loss of liquid and causes dark brown spots and dry skin. One pear fruit can be attacked several times. *D. baccarum* feeds for a few minutes to an hour, and the symptoms appear after a few days (Yu et al, 2002).

Hosts

D. baccarum is polyphagous. Recorded hosts include a range of vegetables and flowers as well as *Glycine max*, *Oryza sativa*, *Phaseolus* sp. (CPC, 2007); *Pyrus* sp.(Hua, 2000), *Malus* sp. (Yi, 1997); *Pyrus pyrifolia* (AQSIQ, 2007); *P. bretschneideri* (AQSIQ, 2007); *Fragaria* sp. (Gertsson, 1979).

Plant parts affected

Leaves, young shoots, fruit (Yu et al, 2002).

Geographical distribution

Asia: China (Heilongjiang, Jilin, Liaoning, Inner Mongolia, Henan, Hebei, Shandong, Ningxia, Shaanxi, Gansu, Xiniang, Hubei, Anhui, Jiangsu, Jiangxi, Zhejiang, Fujian, Guangdong, Hainan, Hunan, Guangxi, Guizhou, Sichuan, Yunnan, Xizang) (Hua, 2000; Dong et al, 2000; Yi, 1997; Yu et al, 2002); India, Iraq, Israel, Japan, Korea, Turkey (CPC, 2007).
Europe: Bulgaria, Cyprus, Denmark, France, Italy, Norway, Poland (CPC, 2007); Russia (CPC, 2007; Sadigov, 1990).

Hazard identification conclusion

Dolycoris baccarum has been recorded on *Pyrus*, and is associated with the fruit of host plants. It is present in China. It is not known to be present in New Zealand, and is considered to be a potential hazard.

8.5.2 Risk assessment

Entry assessment

Eggs, nymphs and adults of *D. baccarum* are present in pear orchards in Henan during the harvest period of August and September, with adults remaining active until November (Yu et al, 2002). Further north, where there are fewer generations, eggs are not likely to be present at harvest and nymphs are only likely to be present during the early part of the harvest season.

Adults and nymphs of *D. baccarum* are associated with mature fruit. Adults are 9–12 mm long and are likely to be readily detectable during harvest and packing processes. They can fly short distances when disturbed (Yi, 1997), and it is assumed they would be unlikely to remain on the fruit during harvest. Nymphs are less mobile. They can move slowly, but reportedly “play dead” when disturbed (Yi, 1997; Chen et al, 1990) and may be more likely to remain on harvested fruit. The size of nymphs would depend on the instar, but presumably could be anywhere from 1–2 mm up to 8–9 mm long.

It is unknown whether *D. baccarum* eggs are laid on pear fruit. It is uncertain whether any egg masses that may be present would be small enough to avoid detection during pre-export inspections and packaging processes. The average recorded number of eggs in an egg mass varies between 14 +/- 8 (Chen et al, 1990) and 20–30 (Yi, 1997).

The tendency of adults to over-winter in buildings may mean that they have the potential to be transported as hitchhikers on non-host material.

Given that:

- nymphs and/or adults could be present on pear fruit at harvest;
- adults are large and mobile and unlikely to remain on harvested fruit;
- nymphs are less mobile and could escape detection during the pre-export process;
- egg masses could be present on the fruit and may be difficult to detect;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. Infested fruit are more likely to be thrown away. The waste material generated could allow *D. baccarum* nymphs or adults developing from nymphs, to disperse and find a suitable host. Adults are mobile; they can fly, albeit short distances. They would be able to move off any infested fruit disposed of in the environment in New Zealand. *D. baccarum* has a range of hosts, including species that grow commonly in domestic as well as commercial situation in New Zealand. There is unlikely to be a shortage of suitable hosts nearby.

Given that:

- adults and to a lesser extent nymphs, are mobile;
- their recorded hosts include a number of species that are widespread in New Zealand;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

D. baccarum reproduces sexually so individuals of both sexes would need to be present to establish a reproductive population. For permanent establishment, males must be able to locate females and conditions must be suitable for mating and egg laying to occur. Although eggs are laid in masses, the nymphs are mobile and although there can be multiple puncture wounds on a single fruit, these could be made by a single individual. There is little evidence that multiple individuals would enter on a fruit. However, if one fruit is infested it is likely that others harvested at the same time and place will also be infested. This may increase the likelihood of multiple individuals arriving and of finding a mate. Depending on the climate, there can be multiple generations a year, which would increase the rate of population build up.

D. baccarum occurs in temperate countries and it is assumed that climatic conditions are unlikely to be a barrier to establishment in New Zealand.

Given that:

- *D. baccarum* reproduces sexually;

- climate is unlikely to be a barrier to establishment in at least some areas;
- multiple generations a year may enable rapid population build up;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

D. baccarum damages several species of commercial importance in New Zealand including apples, pears and strawberries. The extent of the damage is unclear, but damaged fruit are unlikely to be marketable.
The potential economic impact in New Zealand is uncertain but considered to be low.

Environmental consequences

A complete host list is not available for *D. baccarum*. Significant effects on plant health have not been reported.
The potential environmental impacts are uncertain but considered to be low.

Human health consequences

There are no known human health issues for this shield bug, but it could become a nuisance if it over-winters inside buildings.

Risk estimation

Dolycoris baccarum has a low likelihood of entry, a moderate likelihood of exposure and a low likelihood of establishment in New Zealand. The potential impacts are likely to be low. *As a result the risk estimate for D. baccarum is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

It is not known whether eggs are laid on pear fruit.

8.5.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

The distribution of *D. baccarum* is uncertain, but it has been reported from several of the main areas where pears are grown for export. Pest-free areas may be a viable option for some fruit if its distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4). In particular no records were found for its presence in Xinjiang, the main growing area for pears for export of *Pyrus* sp. nr. *communis.*

Bagging of fruit

Fruit are bagged up to one month after fruit set (see section 2.2.3 and section 4.4). *D. baccarum* adults are relatively large. The practice of bagging individual fruit is likely to prevent adults and probably nymphs from accessing the fruit surface. *Pyrus* sp. nr. *communis* fruit are not bagged and bagging will not be a viable option for these fruit.

Phytosanitary inspection prior to export

Adults or nymphs may be associated with fruit. They are relatively large; adults are 9–12 mm long. They are predominantly brown in colour with dark and pale brown bands bordering part of the abdomen, antennae and legs (Virtual Fauna of Lakeland, undated). Visual inspection is likely to detect adult *D. baccarum* at least. It is not known whether eggs are laid on fruit. If they are, small egg masses may be difficult to detect.

Cold treatment

D. baccarum is tolerant of temperatures below freezing; cold treatment at temperatures that will not damage the commodity are unlikely to be an effective risk management measure.

A combination of fruit bagging and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

8.6 *Halyomorpha halys – brown marmorated stink bug*

Scientific names: *Halyomorpha halys* (Stal, 1855) (Hemiptera: Pentatomidae)
Other relevant scientific names: *Halyomorpha mista* (Uhler); *Poecilometis mistus* Uhler, 1860; *Dalpada brevis* Walker, 1867; *Dalpada remota* Walker, 1867
Common names: brown marmorated stink bug, shield bug, fruit-piercing stink bug, stink bug

8.6.1 Hazard identification

New Zealand status

Halyomorpha halys is not known to be present in New Zealand. Not recorded in Larivière and Larochelle (2004), PPIN (2008).

Taxonomy

There is some confusion around the names used for this species. It appears in the literature under *H. halys* and three of the junior synonyms and it is still referred to in Japan as *H. mista*. It has been frequently confused with the Indian species *H. picus*, which is not present in China. Records from China are incorrect and the species they refer to is *H. halys*, which is the only species of the genus present in eastern China (Rider and Zheng, 2005).

Biology

The nymphs and adults have a piercing-sucking type of mouthpart which they use to obtain fluid from fruit and leaves. Small necrotic spots on fruit and leaf surfaces result and the damage may be compounded by secondary infections and scarring as the fruit matures (Gyeltshen et al, 2005). Adults are very active and drop from plants, or hide or fly when disturbed (Gyeltshen et al, 2005; Wermelinger et al, 2008).

Only one generation is produced annually throughout most of the native range, (China, Korea, Taiwan, and Japan). One to two generations have been reported for central and southern Heibei Province, China (Zhang et al, 1993; quoted in Hoebeke and Carter, 2003) and up to six generations per annum in south China, near Canton. There, eggs have been observed at the end of September and nymphs as late as mid-October (Hoffman, 1931; quoted in Hoebeke and Carter, 2003). Females usually lay eggs on the underside of leaves from approximately June to August (Wermelinger et al, 2008). Eggs are approximately 1.6mm long and 1.3mm in diameter (Hoebeke and Carter, 2003). Depending on the host species, females produce 50–150 eggs in masses of 20–30 eggs each (Wermelinger et al, 2008). In the laboratory, females commonly laid egg masses of 28 eggs (Kawada and Kitamura, 1983; Hoebeke and Carter, 2003).

There are five nymphal instars, with average lengths of 2.4 mm, 3.7 mm, 5.5 mm, 8.5 mm, and 12 mm respectively (Hoebeke and Carter, 2003). In laboratory-reared *H. halys*, the nymphal stage lasts from 30 to over 50 days (Kadosawa and Santa, 1981). In autumn, the late instar nymphs and the adults often move from pome and stone fruit to woody ornamentals, where they feed on berries (Funayama, 2002; cited in Wermelinger et al, 2008). Host switching in search of the most nutritious fruit can occur throughout the whole growing season (Funayama, 2002; cited in Wermelinger et al, 2008).

The adults of *H. halys* feed mainly on fruit (Wermelinger et al, 2008) and have been observed on fruit of apples, pears, peach and persimmon in Japan (Kawada and Kitamura, 1983). Damage to Fuji apple fruit was observed in early to mid-August and symptoms were significant pitting and discolouration of flesh (Funayama, 1996).

Adults are the over-wintering life stage. In Asia, they aggregate in houses, sheds, commercial establishments or natural crevices, where they enter diapause (Wermelinger et al, 2008). They can be a serious nuisance in Japan in autumn when they aggregate (Hoebeke and Carter, 2003) as they discharge a foul-smelling scent when disturbed. They mate in the spring.

In addition to their direct effect on host plants, *H. halys* is reportedly a vector of several phytoplasma diseases in China.

Hosts

H. halys is highly polyphagous. Recorded hosts include ornamental and fruit trees as well as vegetable crops:
Acer spp., *Citrus* spp. (Wermelinger et al, 2008); *Diospyros* (Kawada and Kitamura, 1983); *Glycine max* (Osakabe and Honda, 2002); *Malus* (CPC, 2007; Funayama, 1996; Kawada and Kitamura, 1983); *Morus* sp., *Phaseolus vulgaris, Pisum sativum, Prunus domestica, Prunus persica* (Wermelinger et al, 2008); *Prunus persica* (Kawada and Kitamura, 1983); *Pyrus* (Hua, 2000); *Pyrus communis* (Kawada and Kitamura, 1983; Takabe, 2005; Wermelinger et al, 2008); *Pyrus bretschneideri, Pyrus pyrifolia* (AQSIQ, 2007), *Rubus* spp.(Wermelinger et al, 2008).
In the USA the most preferred crops are peach, pear, and apple (Wermelinger et al, 2008).

Plant parts affected

Adults on fruit (Kawada and Kitamura, 1983); eggs on leaves (Funamaya, 2002). Nymphs feed on leaves, stems and fruits (Hoebeke and Carter, 2003).

Geographical distribution

Asia: China (Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hebei, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Jilin, Liaoning, Shaanxi, Shanxi, Sichuan, Xizang, Yunnan, Zhejiang, Inner Mongolia, Beijing, Fujian, Hong Kong, Guizhou) (Rider and Zheng, 2005; Hua, 2000); Japan (CPC, 2007; Funayama, 1996; Kawada and Kitamura, 1983; Osakabe and Honda, 2002).
Europe: Switzerland (Wermelinger et al, 2008).
North America: USA (Wermelinger et al, 2008).

Hazard identification conclusion

Halyomorpha halys has been recorded on *Pyrus*, and is associated with the fruit of host plants. It is present in China, not known to be present in New Zealand, and is considered to be a potential hazard.

8.6.2 Risk assessment

Entry assessment

Depending on the location of the orchard and the timing of the harvest, eggs, nymphs and adults may be present at the time of harvest. *H. halys* eggs are laid on leaves and are unlikely to be associated with fruit. The eggs are laid in masses of about 28 so it is assumed that if they are present on fruit they would be detected during the harvest and packing process.

Both nymphs and adults are associated with fruit, although adults may be more prevalent. Adults are 12 to 17 mm in length (Hoebeke and Carter, 2003) and should be highly visible. When disturbed on leaves, they drop off the leaves or rapidly hide (Wermelinger et al, 2008), and there is no reason to assume they would not do the same if disturbed on fruit. On warm days, the adults may take short flights (Wermelinger et al, 2008). It is assumed that adults are unlikely to remain on the fruit during harvest, and if they do, would be seen when packing fruit for export. Therefore it is unlikely that adults would enter New Zealand on this pathway.

In southern China, near Canton (Guangdong province), where there are up to six generations per year, nymphs have been observed as late as mid-October. *Pyrus* fruit is harvested from late August to December, depending on the species (see Chapter 2 for details). The provinces in which pears for export are primarily grown are much further north. One to two generations reported for Heibei Province are more likely. In Heibei, adults reportedly seek over-wintering sites from late August to late October (Zhang et al, 1993; quoted in Hoebeke and Carter, 2003). Nymphs are mobile and are likely to move off fruit when disturbed during harvest. However, nymphs lack fully developed wings (Gyeltshen et al, 2005) and it is not known whether they drop off the fruit when they are disturbed in the same way that adults drop off leaves (Wermelinger et al, 2008). The size of nymphs will depend on their stage of development (2.4 mm–12 mm). First instar nymphs tend to congregate near eggs (Gyeltshen et al, 2005; Chen et al, 1990), which are laid on leaves. Therefore first instar nymphs are unlikely to be found on fruit. Feeding causes small necrotic spots on the fruit surface, which may give an indication of the presence of *H. halys.*

In autumn, late instar nymphs and adults reportedly often move from pome and stone fruit to woody ornamentals, where they feed on berries. The prevalence of adults and nymphs on pear fruit will depend on the timing of such movement in relation to the timing of harvest.

H. halys has recently established in North America (Hoebeke and Carter, 2003), and Switzerland (Wermelinger et al, 2008). Although it is not known how it entered these countries, it is suggested that it may have arrived in North America with bulk freight containers from Japan, Korea, or China since it has reportedly been intercepted at the American border on machinery, cargo and wooden crates, tractor soil (Hoebeke and Carter, 2003). It has been suggested that it entered Switzerland with woody or floral ornamentals or fruit (Wermelinger et al, 2008). The fact that adults over-winter in sheds and houses suggest that diapausing adults hitchhiking in crevices in containers or other inanimate objects is a more likely pathway for long distance transfer rather than fruit. Depending on the timing of harvest in relation to when adults leave the host plant to over-winter, there may be an opportunity for them to hitchhike in boxes of harvested fruit, but there is currently no evidence for this.

Given that:

- nymphs and adults are likely to be associated with pear fruit at harvest, albeit possibly at low prevalence depending on the timing of harvest;
- adults are relatively large and mobile and not likely to remain on the fruit during the harvest and packing process;
- nymphs are less mobile and smaller, but less likely to be associated with fruit, and necrotic spots on the fruit may give an indication of their presence;
- interceptions on inanimate objects and the fact that adults over-winter in sheds and houses suggest that hitchhiking of over-wintering adults is a more likely means of long distance transfer, rather than fruit;

The likelihood of entry is considered to be negligible.

Risk estimation

Halyomorpha halys has a negligible likelihood of entry. *As a result the risk estimate for H. halys is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *Halyomorpha halys* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

A key assumption is that *H. halys* is likely to be transported internationally as a hitchhiker on commodities other than its host material. Since this is an important pest that is currently expanding its range it is important to clarify this uncertainty. This may be achieved by formally identifying any stinkbugs intercepted on imported commodities, whether host material or inanimate. If this assumption is incorrect this assessment will need to be revised.

8.7 *Icerya aegyptiaca* – *Egyptian cottony cushion scale*

Scientific name:	*Icerya aegyptiaca* (Douglas, 1890) (Hemiptera: Margarodidae)
Other relevant scientific names:	*Crossotosoma aegyptiacum* Douglas, 1890; *Icerya tangalla* Green, 1896 (ScaleNet, 2009)
Common names:	breadfruit mealybug, Egyptian cottony cushion scale, Egyptian Icerya, Egyptian cushion scale, Egyptian fluted scale, Egyptian mealybug

8.7.1 Hazard identification

New Zealand status

Icerya aegyptiaca is not known to be present in New Zealand. Not recorded in: Morales (1991), PPIN (2008).

Biology

Icerya aegyptiaca is a serious pest of citrus, fig and shade trees in Egypt and is considered a pest of breadfruit, avocado, banana, citrus and ornamentals in the Pacific Region (CPC, 2007). Adult females are orange red or brick red with limbs and antennae blackish, the dorsum more or less completely covered with cushions of white (adult) or yellow and white (immature) mealy secretion intermingled with powdery or granular wax (ScaleNet, 2009). Adult females are 4–5 mm long, and 3–4 mm wide (Iceryine Online, 2008).

Icerya species have three immature stages. Development from egg to adult usually takes about three months. As with all scale insects, the females are wingless and appear similar to the immature stages. Males are unknown and are not required for reproduction (CPC, 2007).

Damage to the plant is caused by sap depletion; shoots dry up and die, and defoliation occurs and trees may be dwarfed. In addition, copious quantities of honeydew are produced by the scales, resulting in the growth of sooty moulds over the surfaces of the leaves, reducing photosynthesis (CPC, 2007).

Hosts

Icerya aegyptiaca has a very wide host range, especially woody plants, from 50 families and at least 106 genera. The major hosts are *Annona muricata* (soursop), *Artocarpus altilis* (breadfruit), *Artocarpus heterophyllus* (jackfruit), *Citrus* spp., *Mangifera indica* (mango), *Manilkara zapota* (sapodilla), *Morus alba* (mora), *Psidium guajava* (guava) (CPC, 2007).

Hall (1922) records *I. aegyptiaca* infesting *Pyrus communis* but does not include it amongst the plants that are most susceptible. No other records of the infestation of *Pyrus* species were found. CPC (2007) does not list *Pyrus* amongst the hosts, but notes that its host list is not exhaustive.

Plant parts affected

Leaves, stems and whole plant are affected at flowering, fruiting and vegetative growing stages (CPC, 2007). Hall (1922) states that leaves, young stems or fruit are attacked.

Geographical distribution

I. aegyptiaca is widespread in Asia, Oceania and Africa and not present in Europe (ScaleNet, 2009; CPC, 2007).

China: Guangdong, Taiwan and Hong Kong (CAB Map 221), Jiangsu, Zhejiang, Jiangxi, Fujian, Hunan, Guangxi (Hua, 2000). None of these areas are the main pear growing provinces.

Hazard identification conclusion

Icerya aegyptiaca is present in China and is not known to be present in New Zealand. It is reported on *Pyrus communis* and in association with fruit. It is considered a potential hazard.

8.7.2 Risk assessment

Entry assessment

Only one reference has been found for *Icerya aegyptiaca* in association with *Pyrus* and it appears that *Pyrus* is not a major host. Its distribution is primarily tropical or subtropical and it has not been recorded from the main pear exporting areas in China. Consequently, it is assumed that it is unlikely to be prevalent in pear orchards. Adults are highly visible, being brightly coloured and covered with a powdery secretion.

Given that:

- there is limited evidence for an association between *I. aegyptiaca* and pear fruit;
- it does not occur in the main pear growing areas of China;
- any adults that are present are likely to be detected during the harvest and packing process;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Icerya aegyptiaca* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for I. aegyptiaca is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *Icerya aegyptiaca* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

The association of *Icerya aegyptiaca* with *Pyrus* is uncertain.

8.8 *Lepidosaphes conchiformis – fig scale*

Scientific name:	*Lepidosaphes conchiformis* (Gmelin, 1790) (Hemiptera: Diaspididae)
Other relevant scientific names:	*Coccus conchiformis* Gmelin, 1790; *Lepidosaphes conchiformioides* Borchsenius, 1958; *Lepidosaphes conchiformis ulmi* Koroneos, 1934; *Lepidosaphes ficifoliae ulmicola* Leonardi, 1907; *Lepidosaphes rubri* Thiem, 1931; *Lepidosaphes turkmenica* Borchsenius and Bustshik, 1955; *Mytilaspis ficifolii* Berlese, 1903; *Mytilaspis ficus* Signoret, 1870; *Mytilaspis minima* Newstead, 1897 (ScaleNet, 2009)
Common names:	fig oystershell scale, fig scale, greater fig mussel scale, Mediterranean fig scale, pear oystershell scale, red oystershell scale (ScaleNet, 2009)

8.8.1 Hazard identification

New Zealand status

Lepidosaphes conchiformis is not known to be present in New Zealand. Not recorded in: Charles and Henderson (2002), PPIN (2008).

Biology

Lepidosaphes conchiformis is an economically important pest in France (AEI, 2008) and the USA (University of California, 2009b). It has morphologically distinct leaf and twig forms; the twig form has a dark brown female scale cover 1.2–2.7 mm long, whereas the in-leaf form scale cover is white; the exuviae are terminal. In both forms the male scale cover is elongate, light tan or purplish-white or white with terminal exuviae and 0.7–1.0 mm long (ScaleNet, 2009).

In Japan, Murakami (1970) states that *L. conchiformis* has two generations per year, overwintering as fertilised female adults. The female lays about 60 eggs beneath the scale the following April. The eggs hatch in May-June (first generation) and August to September (second generation). Kuwana (1925) reports it having one generation per year, overwintering as fertilised females.

In California, there are three to four generations per year, and the insect overwinters on one- to two-year-old wood (Farrar, 1999). On elm trees in Iran, females that had not yet oviposited overwintered on the trunk and branches of the host-plant, but their offspring dispersed over the leaves (Balali and Seyedoleslami, 1986). In Europe, there are one or two generations per year and the overwintering female lays about 25 eggs in spring (AEI, 2008). ScaleNet (2009) states that about 60 eggs are laid beneath the scale cover. Each female produces 5–8 eggs in Poland; an average of 26 are laid in Germany (AEI, 2008).

On *Tilia* in Poland, adult females were present from mid-July to early May, eggs from the end of April to late May, nymphs from mid-May to early August and adult males in late July or early August. *L. conchiformis* had one generation per year and the females overwintered. Although males were present only for a short time no parthenogenetic reproduction occurred (Komosinska, 1975).

Scale feeding on fig causes a callous tissue to form on the skin, giving the fruit a warty appearance (Farrar, 1999).

Hosts

L. conchiformis has a wide host plant range, consisting of woody plants from 33 genera and 20 families. Fig is the favoured host in California (AEI, 2008). The hosts include *Pyrus communis* and *Pyrus pyrifolia* (ScaleNet, 2009). *Pyrus serotina*, *Pyrus* sp. (Hua, 2000; Murakami, 1970).

Plant parts affected

Leaves and branches of woody hosts are the usual parts affected (AEI, 2008). In figs the fruit are commonly affected (University of California, 2009b). Murakami (1970) states that *L. conchiformis* is found on fruit of host plants, while Kuwana (1925) states that it is common in pear orchards and occurs on the small branches and fruit of Japanese pear; Balali and Seyedoleslami (1986) state that the trunk, branches and leaves are infested and Kawaguchi (1935) records twigs and fruit being infested.

Geographical distribution

L. conchiformis is present in the United States of America, Central America, South America and Africa. It is widespread in Asia (Middle East, southeast) and in Europe, including northern countries with climates similar to New Zealand (ScaleNet, 2009).

It is recorded in China in Heilongjiang, Jilin, Xingjiang, Ninxia, Shanxi, Jiangsu, Jianxi, Guangdong, Hunan, Yunan, Xizang, Anhui, Fujian, Gansu, Hebei, Henan, Hubei, Liaoning, Shandong, Sichuan and Zhejiang provinces (Hua, 2000).

Hazard identification conclusion

Lepidosaphes conchiformis infests the fruit of at least some host plants and is present in China. It has been recorded on *Pyrus communis* and *P. pyrifolia* and is not present in New Zealand; it is considered to be a potential hazard.

8.8.2 Risk assessment

Entry assessment

L. conchiformis has been recorded from some of the main pear growing provinces of China.

It is recorded as infesting pear fruit in Japan. However, it appears that leaves and branches are more commonly affected. It is unclear how many generations occur in the pear growing areas of China, but regardless of the number of generations, fertilised females appear to be the over-wintering life stage. This being the case, they are likely to be present on mature fruit at harvest.

The scales are small (less than 2 mm diameter), and might not be detected during the pre-export process. A journey time of about four weeks is unlikely to be a barrier to survival and a gravid female could lay eggs during shipment.

Given that:

- female scales infest pear fruit, but fruit are not the preferred plant part;
- scales are not easy to detect;
- adults scales are likely to survive transfer to New Zealand;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Damaged or uneaten fruit and peel disposed of in New Zealand provides an exposure route for *L. conchiformis* entering on imported pears. Gravid females would need to be present on fruit and the infected fruit would need to be in close contact with a suitable host so that hatched crawlers could crawl or be blown to the host. The passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. Crawlers are susceptible to extremes of temperature, desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage (APHIS, 2007).

The wide host range of *L. conchiformis,* including many genera which are widely distributed in home gardens in New Zealand (e.g. *Acer, Betula, Citrus, Corylus, Fagus, Ficus, Fraxinus, Juglans, Malus, Prunus, Tilia* and *Ulmus* (AEI, 2008)), increases the likelihood of any nearby tree being a suitable host. The effect of seasonal inversion is not known, but as gravid females are the primary overwintering stage it is likely that they would be a life stage that would be present on harvested fruit and spring conditions in New Zealand would stimulate egg laying.

Given that:

- gravid females present on fruit would need to lay eggs on arrival in New Zealand;
- crawlers can move short distances actively or long distances passively;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality;
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant;
- *L. conchiformis* has a wide host range and suitable hosts are widely distributed in New Zealand;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

Females lay tens of eggs together, underneath the maternal scale. This will increase the likelihood of individuals of the opposite sex mating and establishing a population. The host range of *L. conchiformis* is relatively wide and hosts such as *Malus* and *Prunus* are well represented in New Zealand. Its global distribution includes areas with more extreme climates than New Zealand; it is assumed that establishment is unlikely to be limited by the New Zealand climate.

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

The impact of *L. conchiformis* is unclear. Its host range includes several genera that are important commercially in New Zealand such as *Malus*, and *Citrus* as well as a number of ornamental plants. However, it appears to be primarily a pest of figs and the scale of impacts on other hosts are unknown.
The potential economic impact within New Zealand is considered to be low.

Environmental consequences

L. conchiformis has a wide host range. Some of the host families have plants in the native flora; there may be some environmental consequences should this scale insect establish in New Zealand.
The potential environmental impact within New Zealand is uncertain.

Human health consequences

No human health consequences are envisaged for this scale insect.

Risk estimation

Lepidosaphes conchiformes has a low likelihood of entry and exposure and moderate likelihood of establishment in New Zealand. The potential economic impact within New Zealand is low. *As a result the risk estimate for L. conchiformes is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified*.

Assessment of uncertainty

The extent to which *L. conchiformes* infests pear fruit in China is unknown. The potential of this scale insect to extend its current host range to some of New Zealand's native flora is unknown.

8.8.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

L. conchiformes appears to be widely distributed in China. Pest free area status is unlikely to be a viable option.

Bagging of fruit

Fruit are bagged up to one month after fruit set (see section 2.2.3 and section 4.4). Crawlers are unlikely to enter the bag between bag and stalk. However, they could access the fruit prior to bagging. Inspection of surrounding leaves and fruit when bags are changed would give prior warning of an infestation.

High pressure air blasting

Use of high pressure air guns in the pack houses would be expected to remove crawlers which are blown in the wind, but adults would be unaffected.

Phytosanitary inspection prior to export

The scale insects are likely to be visible on the fruit, but they could be missed if few are present, since they are only a few millimetres in size.

Cold treatment

Since adult females over-winter in their native range, they are likely to be able to survive refrigerated shipment to New Zealand or other cold treatment. This is therefore not considered a viable measure.

A combination of fruit bagging, air brushing and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

8.9 *Lepidosaphes malicola – Armenian comma scale*

Scientific name:	*Lepidosaphes malicola* Borchsenius, 1947 (Hemiptera: Diaspididae)
Other relevant scientific names:	*Lepidosaphes kalandadzei* Hadzibejli, 1960; *Lepidosaphes kirgisica* Borchsenius, 1949 (ScaleNet, 2009)
Common names:	Armenian comma scale, Armenian mussel scale, kirgis comma scale (ScaleNet, 2009).

8.9.1 Hazard identification

New Zealand status

Lepidosaphes malicola is not known to be present in New Zealand. Not recorded in: Charles and Henderson (2002), PPIN (2008).

Biology

L. malicola is reported as one of the most important and widespread apple pests in Iran and as very damaging to apple in Armenia, and to *Ribes* and *Salix* in Tajikistan. The species is described as a pest in the Palaearctic region (AEI, 2008). It is polyphagous, infesting all parts of apple, pear, peach, apricot, plum, cherry and many other fruit, walnuts and other trees and bushes (Babayan and Oganesyan, 1979).

The female scale is comma-like, dark yellow, 2.2–3.0 mm long and 0.9–1.4 mm wide (ScaleNet, 2009). The scale cover of the male, if present, is light brown, smaller, more slender and more parallel-sided than that of female, with yellow terminal exuviae (AEI, 2008).

In Iran, each female produces 14–140 eggs; there are two generations per year on apple, and the eggs overwinter (AEI, 2008). In Armenia, the eggs overwinter beneath the maternal scale and hatch in spring. Crawlers are the primary dispersal stage and move to new areas of the plant or are dispersed by wind or animal contact. Dispersal of sessile adults and eggs occurs through human transport of infested plant material (AEI, 2008). Mortality is usually slight, and large populations may develop. Development lasts 54–57 days in the first generation and 51–56 days in the second (Babayan and Oganesyan, 1979). The summer generation sometimes spreads to the leaves and fruit. One study showed that damage to walnuts decreased with altitude in Armenia (AEI, 2008).

Hosts

L. malicola is polyphagous and has been recorded from woody hosts (fruit and ornamental trees, and shrubs) in 18 families and 31 genera (AEI, 2008; ScaleNet, 2009), including *Lonicera*, *Rhododendron*, *Syringa*, *Salix*, *Populus* (ScaleNet, 2009) and *Pyrus* (Borchsenius, 1966; Babayan and Oganesyan, 1979). Members of the Rosaceae are favoured hosts (AEI, 2008), e.g. *Armeniaca vulgaris, Malus* sp., *Mespilus germanica, Persica* sp., *Prunus persica, Pyrus* sp., *Rosa* sp. (ScaleNet, 2009).

Plant parts affected

Scale insects occur commonly on the trunk and branches, and sometimes also on the leaves and fruit (AEI, 2008). Babayan and Oganesyan (1979) stated that all plant parts are affected and Mostaan and others (1972) note that the trunk, branches and fruit can be infested.

Geographical distribution

L. malicola is a temperate species, probably of Asian origin (AEI, 2008). It has been recorded from:
Asia: Azerbaijan, China, Georgia, India, Iran, Israel, Kazakhstan, Kyrgyzstan, Tajikistan, Turkey, Turkmenistan, Uzbekistan.
Europe: Armenia, Bulgaria, Transcaucasus, USSR (former republic).
(combined list from AEI (2008) and ScaleNet (2009))

It is recorded in China in Xinjiang province (Hua, 2000).

Hazard identification conclusion

Lepidosaphes malicola is a pest of *Pyrus*, and has been recorded on the fruit of its hosts. It is present in China in Xinjiang, which is a pear growing province. No record was found of the species of *Pyrus* that are infested; however, it is polyphagous and it is assumed that it will infest all three species that China wishes to export to New Zealand. It is not present in New Zealand and is considered to be a potential hazard.

8.9.2 Risk assessment

Entry assessment

L. malicola is known to be present at least in Xinjiang, the main province growing *Pyrus* sp. nr. *communis* for export. Its prevalence is not known, but members of the Rosaceae are reportedly favoured hosts (AEI, 2008). Adult scales with or without eggs are the most likely life stage to be associated with mature fruit. Since eggs are the over-wintering stage they are likely to be present at harvest time. The scales are small (less than 3 mm diameter), and might not be detected during the pre-export process. A journey time of about four weeks is unlikely to be a barrier to survival and a gravid female could lay eggs during shipment.

Given that:

- female scales with or without eggs could be present on pear fruit at harvest;
- scales are not easy to detect;
- adults and eggs are likely to survive transfer to New Zealand;

The likelihood of entry is considered to be moderate and therefore non-negligible.

Exposure assessment

Damaged or uneaten fruit and peel disposed of in New Zealand provides an exposure route for *L. malicola* entering on imported pears. Crawlers, hatching from eggs, or gravid females would need to be present on fruit and the infected fruit would need to be in close contact with a suitable host so that hatched crawlers could crawl or be blown to the host. The passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. Crawlers are susceptible to extremes of temperature, desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage (APHIS, 2007).

The wide host range of *L. malicola,* including many genera which are widely distributed in home gardens in New Zealand increases the likelihood of any nearby tree being a suitable host. The effect of seasonal inversion is not known, but as eggs are the primary overwintering stage it is likely that they would be a life stage that would be present on harvested fruit and it is possible that spring conditions in New Zealand would stimulate hatching.

Given that:

- eggs present on fruit may hatch on arrival in New Zealand;
- crawlers can move short distances actively or long distances passively;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality;
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant;
- *L. malicola* has a wide host range and suitable hosts are widely distributed in New Zealand;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

Females lay large numbers of eggs together, underneath the maternal scale. This, together with the flight ability of males will increase the likelihood of sufficient adults developing to establish a population. The host range of *L. malicola* is relatively wide and favoured rosaceous hosts such as *Malus* and *Prunus* are well represented in New Zealand. Its global distribution includes areas with more extreme climates than New Zealand; it is assumed that establishment is unlikely to be limited by the New Zealand climate.

The likelihood of establishment is considered to be high and therefore non-negligible.

Consequence assessment

Economic consequences

L. malicola infests pear, apple, *Prunus* and *Ribes* species as well as ornamental plants such as *Lonicera*, *Rosa, Rhododendron* and *Syringa,* and shelter and erosion control trees such as *Salix* and *Populus.* Plants grown commercially for fruit are assumed to already have control programmes for scale insects, so another scale insect may not have serious consequences. However, plants that do not receive control measures could be seriously affected. In the former USSR, heavy infestations cause death of branches or even entire trees; infestation of fruit causes red spotting (AEI, 2008).
The potential economic impact within New Zealand is considered to be moderate.

Environmental consequences

L. malicola has a wide host range. None of the genera recorded as hosts are represented in New Zealand's native flora. Eight of the 18 families have plants in the native flora; there

may be some environmental consequences should this scale insect establish in New Zealand.
The potential environmental impact within New Zealand is uncertain.

Human health consequences

No human health consequences are envisaged for this scale insect.

Risk estimation

Lepidosaphes malicola has a moderate likelihood of entry, low likelihood of exposure and high likelihood of establishment in New Zealand. The potential economic impact within New Zealand is moderate. *As a result the risk estimate for L. malicola is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

No record was found of the species of *Pyrus* that are infested; however, *L. malicola* is polyphagous and it is assumed that it will infest all three species that China wishes to export to New Zealand. Its prevalence and distribution within China is also uncertain. The potential of this scale insect to extend its current host range to some of New Zealand's native flora is unknown.

8.9.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

Records have only been found for *L. malicola* in Xinjiang province. If its absence from other provinces can be verified in accordance with ISPM No. 4 (see section 4.2) then pest free area status for some pears may be a viable option.

Bagging of fruit

Fruit are bagged up to one month after fruit set (see section 2.2.3 and section 4.4). Crawlers are unlikely to enter the bag between bag and stalk. However, they could access the fruit prior to bagging. Inspection of surrounding leaves and fruit when bags are changed would give prior warning of an infestation. *Pyrus* sp. nr. *communis* fruit are not bagged and this is not a viable option for these fruit.

High pressure air blasting

Use of high pressure air guns in the pack houses would be expected to remove crawlers which are blown in the wind, but adults, or eggs under the scale which are the stage likely to be transported on fruit would be unaffected.

Phytosanitary inspection prior to export

The scales are likely to be visible on the fruit; however, they could be missed if few are present.

Cold treatment

Since eggs over-winter in their native range, they are likely to be able to survive refrigerated shipment to New Zealand or other cold treatment. This is therefore not considered a viable measure.

A combination of fruit bagging, air brushing and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

8.10 *Lepidosaphes pyrorum – Zhejiang pear oyster scale*

Scientific name: *Lepidosaphes pyrorum* Tang, 1977 (Hemiptera: Diaspididae)
Common names: Zhejiang pear oyster scale, pear oyster scale

8.10.1 Hazard identification

New Zealand status

Lepidosaphes pyrorum is not known to be present in New Zealand. Not recorded in: Charles and Henderson (2002), PPIN (2008).

Biology

Lepidosaphes pyrorum was reported as a new pest of pears in Shanxi province in 1991 (Shi and Fan, 1991). Their study was the only available information found on this species.

In Shanxi, there is one generation a year. *L. pyrorum* over-winters as an egg under the scale of the female. The eggs hatch in May. Nymphs emerge from the scale and crawl up to 30 cm on the branches, trunk, leaves and fruit, to find a place in which to feed (Shi and Fan, 1991). In many species of diaspid, nymphs can also be windblown to adjacent trees. Once a suitable location is found, the crawlers settle down, insert their mouthparts into the host plant to feed (Dennie, 2003). The nymphs have a waxy coating. Adult males can fly in search of a mate, but females remain sessile. The optimal temperature for flight is apparently 25°C; flights are short or non-existent at 15°C, and the males remain inactive under leaves at 29°C or higher. Males live a maximum of 4 days. The mated female oviposits in August over a 2-week period. A single female lays between 100 and 250 eggs. Young growing tissues are the preferred location on the host plant (Shi and Fan, 1991).

The damage caused by *Lepidosaphes pyrorum* is assumed to be similar to that for other scale insects in the genus *Lepidosaphes*: chlorosis of leaves, shoot dieback, death of branches and marking of fruit.

Hosts

Pyrus sp. (Rosaceae) (Hua, 2000; Xie, 1982) and *Ulmus pumila* (Ulmaceae) (ScaleNet, 2009). No other host records were found. A search of CAB abstracts gave no results.

Plant parts affected

Branches, trunk, leaves and fruit (Shi and Fan, 1991).

Geographical distribution

Asia: China (Henan and Shanxi provinces) (Hua, 2000; Shi and Fan, 1991).

Hazard identification conclusion

Lepidosaphes pyrorum has been recorded on fruit of *Pyrus*, and is present in China. It is not present in New Zealand, and is considered to be a potential hazard.

8.10.2 Risk assessment

Entry assessment

Lepidosaphes pyrorum has been recorded only in China and reported from Shanxi and Henan Provinces, which are pear growing areas. It is not known which species of *Pyrus* it infests.

L. pyrorum has been recorded on pear fruit, although young growing tissue is the preferred feeding site. Oviposition occurs in August in Shanxi province, so any scales present on fruit at harvest are likely to have eggs. Eggs are the over-wintering life stage and would be expected to survive transit to New Zealand.

Scales are small (usually only a few millimetres in diameter) (Dennie, 2003) and might not be detected during the pre-export process.

Given that:

- *L. pyrorum* scales occur on pear fruit, but fruit are not the preferred plant part;
- eggs would be expected to be present at harvest and to survive transit to New Zealand;
- scales are small and might not be detected;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Damaged or uneaten fruit and peel disposed of in New Zealand provides an exposure route for *L. pyrorum* entering on imported pears. Crawlers, hatching from eggs, would need to be present on fruit and the infested fruit would need to be in close contact with a suitable host so that hatched crawlers could crawl or be blown to the host. The passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. Crawlers are susceptible to extremes of temperature, desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage (APHIS, 2007).

The narrow known host range of *L. pyrorum* reduces the likelihood of any nearby tree being a suitable host. The effect of seasonal inversion is not known, but spring conditions in New Zealand may stimulate hatching.

Given that:

- eggs present on fruit may hatch on arrival in New Zealand;
- crawlers can move short distances actively or long distances passively;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality;
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant;
- *L. pyrorum* has a limited host range;

The likelihood of exposure is considered to be very low and therefore non-negligible.

Establishment assessment

Females lay large numbers of eggs together, underneath the maternal scale. This, together with the flight ability of males will increase the likelihood of sufficient adults developing to establish a population. *L. pyrorum* is only known to have a single generation a year which will limit the rate at which a population can build up and decrease the likelihood that establishment will be successful. The known host range of *L. pyrorum* is limited to *Pyrus* spp. and *Ulmus pumila.* It is not known whether this is an accurate reflection of its host range or merely a reflection of limited reporting. Male flight activity is temperature dependent, but is unlikely to limit the ability to establish in at least parts of New Zealand.

Given that:

- the biology of *L. pyrorum* will increase the likelihood of successful mating;
- only one generation a year has been reported;
- it has a narrow reported host range;
- climate is unlikely to be limiting, at least in parts of New Zealand;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

L. pyrorum is only known to be a pest of pears. Hosts available in New Zealand include *Pyrus communis* and *P. pyrifolia* and its crosses. The size of the New Zealand pear industry (*Pyrus communis*) was 412 ha in 2008 (Pipfruit New Zealand Incorporated, 2008). There is no recent available information on the size of the nashi industry in New Zealand. In 2002, there were 119 ha of nashi (*Pyrus pyrifolia*) grown commercially in New Zealand (Statistics New Zealand, 2002). This is likely to have declined in line with the European pear industry, which has more than halved since 2002 (from 965 ha in 2002 to 412 ha in 2008) (Pipfruit New Zealand Incorporated, 2008). The scale of impacts on pears is not known, but the consequences will be limited by the limited host range. Whilst the impact for individual pear growers might be high, the potential economic impact to New Zealand is considered to be low.

The potential economic impact within New Zealand is considered to be low.

Environmental consequences

There are no species native to New Zealand in the two known host genera.

The potential environmental impact within New Zealand is uncertain but considered to be negligible.

Human health consequences

There are no known human health consequences associated with *L. pyrorum*.

Risk estimation

Lepidosaphes pyrorum has a low likelihood of entry, a very low likelihood of exposure and a low likelihood of establishment in New Zealand. The potential economic impact within New Zealand is low. *As a result the risk estimate for L. pyrorum is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

L. pyrorum has only been reported as a pest relatively recently and there is little available information on it. No record was found of the species of *Pyrus* that are infested, it is assumed that all species may be affected. Its prevalence and distribution within China and its impact on pear trees is uncertain.

8.10.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

Records have been found for *L. pyrorum* in Shanxi and Henan provinces only. If its absence from other provinces can be verified in accordance with ISPM 4 (see Section 4.2) then pest free area status for some pears may be a viable option.

Bagging of fruit

Fruit are bagged up to one month after fruit set (see section 2.2.3 and section 4.4). Crawlers are unlikely to enter the bag between bag and stalk. However, they could access the fruit prior to bagging. Inspection of surrounding leaves and fruit when bags are changed would give prior warning of an infestation. *Pyrus* sp. nr. *communis* fruit are not bagged and this is not a viable option for these fruit.

High pressure air blasting

Use of high pressure air guns in the pack houses would be expected to remove crawlers which are blown in the wind, but adults would be unaffected.

Phytosanitary inspection prior to export

The scales are likely to be visible on the fruit; however, they could be missed if few are present.

Cold treatment

Since eggs over-winter in their native range, they are likely to be able to survive refrigerated shipment to New Zealand or other cold treatment. This is therefore not considered a viable measure.

A combination of fruit bagging, air brushing and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

8.11 *Lopholeucaspis japonica* – Japanese maple scale

Scientific name:	*Lopholeucaspis japonica* (Cockerell, 1897) Balachowsky (1953) (Hemiptera: Diaspididae)
Other relevant scientific names:	*Leucaspis japonicus* Cockerell, 1897; *Leucaspis japonica darwiniensis* Green, 1916; *Leucodiaspis hydrangeae* Takahashi, 1934; *Lopholeucaspis menoni* Borchsenius, 1964
Common names:	Japanese maple scale, pear white scale, Japanese baton shaped scale, Japanese long scale

8.11.1 Hazard identification

New Zealand status

Lopholeucaspis japonica is not known to be present in New Zealand. Not recorded in: Charles and Henderson (2002), PPIN (2008). Spiller and Wise (1982), has an erroneous record.

Biology

Lopholeucaspis japonica is noted as a pest of deciduous fruit trees of regional importance and regarded as one of the most important pests of apple in the western Transcaucasus. Records indicate it can kill branches of maples in USA (Maryland) (AEI, 2008). In Georgia, it is a major pest of citrus, other fruit, tea and ornamental plants (Tabatadze and Yasnosh, 1999). It attacks all citrus, multiplying rapidly to cover the trunk, branches and young shoots with dense colonies. Individual trees are killed by heavy infestations, while neighbouring trees may be virtually unaffected. In Azerbaijan and Georgia, *L. japonica* has caused serious problems, especially on satsuma mandarins, lemons and the citrus rootstock *Poncirus trifoliata*; also on other fruit crops and ornamentals. It was recently introduced in southern Russia, and has caused problems on *Laurus nobilis*.

L. japonica has one generation each year in cooler climates (e.g. Japan and USA (Rhode Island), Far East of Russia) and two in milder climates (e.g. USA: Maryland and Virginia; Georgia (country)) (CABI/EPPO). There are 2–3 generations a year on citrus in Zhejiang province in China (Gan and Zheng, 2007). The development of all stages of the scale is prolonged and there is no clear separation of the generations, and in the latter part of the year all development stages may be present (Tabatadze and Yasnosh, 1999). Crawlers are the primary dispersal stage and move to new areas of the plant or are dispersed by wind or animal contact. Mortality due to abiotic factors is high in this stage. Dispersal of sessile adults and eggs occurs through human transport of infested plant material (AEI, 2008).

L. japonica overwinters mainly as second or third instar nymphs, sometimes as first instar nymphs and occasionally as female adults (Gan and Zheng, 2007) and as mated adult females in Japan. In the Russian Far East, *L. japonica* readily over-winters at temperatures of -20 to -25°C (CPC, 2007). In spring, the adult females lay between 4 and 50 eggs (Tabatadze and Yasnosh, 1999) and the crawler larvae move up to several tens of centimetres to affix themselves on the upper surface of the leaves, along the veins and leaf margin. Scales are also found on the bark of branches and sometimes on fruit.

Hosts

L. japonica is polyphagous, infesting woody trees and shrubs. It has been recorded from hosts in 44 genera belonging to 28 plant families.

Species of citrus are the main crop hosts attacked, although other fruit trees, woody outdoor ornamentals and some glasshouse ornamentals are attacked (CPC, 2007).

Pyrus communis (CPC, 2007); *Pyrus pyrifolia* (*P. serotina*) (Murakami, 1970); *Pyrus* sp.(Hua, 2000), in Beijing on trunk and branches of pears (Borchsenius, 1960); pear trees (Gan and Zheng, 2007)

Plant parts affected

L. japonica can be found on branches, trunk, leaves, stems and fruit/pods (CPC, 2007; AEI, 2008; CABI/EPPO; Murakami, 1970), but occurs mainly on the trunk and main branches where it feeds on sap (Gan and Zheng, 2007; Tabatadze and Yasnosh, 1999).

Geographical distribution

Lopholeucaspis japonica probably originated in the Far East, and has spread to Europe and North America. It is widespread in Asia but not present in the Pacific Islands (AEI, 2008; CPC, 2007; and ScaleNet, 2009).

It is recorded in China in: Liaoning, Hebei, Shandong, Shanxi, Anhui, Henan, Fujian, Guangdong, Guangxi, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan, Zhejiang (ScaleNet, 2009) and Yunnan (AEI, 2008).

Hazard identification conclusion

Lopholeucaspis japonica has been recorded as infesting fruit and it is assumed that it will infest pear fruit. It is present in several of the main pear growing provinces of China. It is not present in New Zealand, and is considered to be a potential hazard.

8.11.2 Risk assessment

Entry assessment

Since *Citrus* is the main host it is assumed that densities will be relatively low in pear orchards, but *L. japonica* is widely distributed in China. No reports of an association between *L. japonica* and mature *Pyrus* fruit have been found. However, based on its lifecycle it is assumed that at harvest time, in the latter part of the year all development stages may be present. *L. japonica* feeds primarily on the trunk and branches, at least on *Citrus*, but scales occasionally occur on fruit. Crawlers are likely to disperse onto fruit and could be carried on fruit. Early instar nymphs are the over-wintering stage, at least in some locations, and may be able to survive transit to New Zealand. Plant parts other than fruit (bark, shoots, twigs and branches) are considered more likely to carry *L. japonica* in trade or transport (CPC, 2007).

Given that:

- *L. japonica* is widely distributed in China but *Pyrus* is not a major host;
- adults and early instar nymphs could be present on pear fruit at harvest, but they are mainly associated with other plant parts;

- these life stages are not easy to detect;

The likelihood of entry is considered to be low but non-negligible.

Exposure assessment

Damaged or uneaten fruit and peel disposed of in New Zealand provides an exposure route for *L. japonica* entering on imported pears. The most likely lifestage associated with imported fruit are early instar nymphs. These crawlers are the most likely dispersal stage. Infested fruit would need to be in close contact with a suitable host so that hatched crawlers could crawl or be blown to the host. The passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. Crawlers are susceptible to desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage (APHIS, 2007).

The wide host range of *L. japonica,* including many genera which are widely distributed in home gardens in New Zealand increases the likelihood of any nearby tree being a suitable host.

Given that:

- crawlers can move short distances actively or long distances passively;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality;
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant;
- *L. japonica* has a broad host range including species widely distributed in New Zealand;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

Females lay up to 50 eggs together, underneath the maternal scale. This clumped distribution will increase the likelihood of successful reproduction. The host range of *L. japonica* is relatively wide and favoured hosts such as *Citrus* spp. are widely distributed at least in the northern part of New Zealand. Its global distribution includes areas with more similar climates to New Zealand e.g. Japan, northern China, United Kingdom. It is assumed that it is unlikely to be limited by the New Zealand climate.

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

L. japonica is a quarantine pest for Europe (AEI, 2008). It causes economic damage in some countries. Several hosts are widely grown in New Zealand e.g. fruit trees: *Pyrus, Malus, Prunus, Citrus* and *Vitis*, but only *Citrus* is known to be a major host. Heavy infestation by *L. japonica* can cause branch dieback (AEI, 2008) and premature leaf fall (CPC, 2007). Low infestations in cracks in the bark do not cause any obvious symptoms and require close examination to detect them (CPC, 2007). CPC (2007) reports that the introduction of *L. japonica* to various countries has not been followed by any rapid spread or very significant damage.

The potential economic impact within New Zealand is uncertain but considered to be moderate.

Environmental consequences

Two of the known host genera are represented amongst the New Zealand native flora (*Euphorbia* and *Pittosporum*). Some species in these genera are of cultural significance and used in amenity planting. Twelve host plant families are represented in the New Zealand flora. Some of the exotic hosts are used as ornamental and specimen trees, e.g. *Acer, Liquidambar, Syringa, Tilia* and *Magnolia* in New Zealand.

The potential environmental impact within New Zealand is uncertain.

Human health consequences

There are no known human health impacts.

Risk estimation

Lopholeucaspis japonica has a low likelihood of entry and exposure, and moderate likelihood of establishment in New Zealand. The potential economic impact within New Zealand is moderate. *As a result the risk estimate for L. japonica is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified*

Assessment of uncertainty

No records were found of *L. japonica* on pear fruit and information on the degree of damage to pear trees was not found.

8.11.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

The main pear growing areas for *Pyrus bretschneideri* and *P. pyrifolia* are the provinces/regions of Hebei, Shandong, Shaanxi, Shanxi, Gansu, Liaoning, Jilin, Beijing, Henan, Anhui and, for *P.* sp. nr. *communis*, Xinjiang Autonomous Region.

As *L. japonica* is not known to occur in Xinjiang, this may be a viable option for *P.* sp. nr. *communis* fruit from this area if the distribution of the pest can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

Bagging of fruit

Fruit are bagged up to one month after fruit set (see section 2.2.3 and section 4.4). The crawlers are unlikely to enter the bag between bag and stalk, especially in conditions of low pest populations, as the fruit is not the favoured feeding site. Inspection of surrounding leaves and fruit when bags are changed would give prior warning of an infestation.

High pressure air blasting

Use of high pressure air guns in the pack houses would be expected to remove crawlers which are blown in the wind, but adults would be unaffected.

Phytosanitary inspection prior to export

L. japonica feeds externally on fruit. Mature scale insects can be 1–3 mm in diameter. Visual inspection may not detect all lifestages.

A combination of fruit bagging, high pressure air blasting and visual inspection would mitigate the risk to a higher degree than any measure in isolation.

8.12 *Maconellicoccus hirsutus – pink hibiscus mealybug*

Scientific name:	*Maconellicoccus hirsutus* (Green, 1908) (Hemiptera: Pseudococcidae)
Other relevant scientific names:	*Maconellicoccus pasaniae* (Borchsenius); *Maconellicoccus perforatus* DeLotto, 1964; *Paracoccus pasaniae* Borchsenius, 1962; *Phenacoccus glomeratus* Green, 1922; *Phenacoccus hirsutus* Green, 1908; *Spilococcus perforatus* De Lotto, 1954

8.12.1 Hazard identification

New Zealand status

Maconellicoccus hirsutus is not known to be present in New Zealand. Not recorded in: Cox (1987), Ben-Dov (1994), PPIN (2008).

Biology

Maconellicoccus hirsutus is a sapsucker that secretes honeydew. It forms colonies on the host plant that grow into large masses of waxy white coverings if left undisturbed. Eggs are laid in a loose cottony ovisac that is attached to the plant surface, usually on twigs, branches and bark of host plant, and also on the leaves and terminal ends. First instar nymphs, or crawlers, are mobile and can be transported over long distances by water, wind (Hall, 1921) and humans or other animal agents. They settle in densely packed colonies in cracks and crevices of the host plant, with a preference for soft tender young tissues, and start to feed and develop. New plant growth becomes severely stunted and distorted as a result of their feeding. Male and female nymphs can be distinguished by the end of the second instar. The male has four nymphal instars while the female has three. At the end of the second instar, males produce cocoons (puparia). Male adults are winged and capable of flight whereas the female is wingless. The lifecycle can be completed in about five weeks under favourable conditions and there may be up to ten generations per year in the subtropics. *M. hirsutus* can overwinter at all lifestages and this can occur inside fruit bunches, bark crevices or in the soil. Both sexual and parthenogenic reproduction have been reported, but it has been assumed that, overall, reproduction is restricted to the sexual form with the sex ratio approximately 1:1. Females can lay 150–600 eggs over the period of a week. Infestations of *M. hirsutus* can be associated with attendant ants, which collect the honeydew they secrete (CPC, 2007; Mani, 1986; Meyerdirk et al, 2001).

M. hirsutus generally prefers apical and tender regions of the plant, but older plant parts may also harbour large populations. As it feeds, *M. hirsutus* injects a toxic saliva into the plant. Both this and direct feeding can cause various symptoms on the host, including malformed leaf and shoot growth, stunting, bushy shoot tips, and occasional death. Sooty mould may develop on leaves and stems due to heavy honeydew secretions. When fruits are infested, they can be covered with the white waxy coating and sooty mould. Infestation can lead to fruit drop, or fruit may remain on the host in dried and shrivelled condition. If flower blossom is attacked, the fruit sets poorly. Thus fruit production and marketability is reduced. If undisturbed, colonies will grow into masses of waxy whitish coverings over most plant structures or even entire plants. Dieback of young shoots and limbs may occur and whole trees may eventually die (Meyerdirk et al, 2001).

Manjunath (1985; cited in Williams (1996)) has reported that in severe attacks, up to 90% of grape clusters are destroyed in the Bangalore area in India. After the vine is pruned, *M. hirsutus* attacks the young developing sprouts, causing stunting of growth (Williams, 1996). Veeresh (1986; cited in Williams (1996)) reported attacks where heavily infested bunches of grapes become unfit for consumption and marketing. *M. hirsutus* has been recorded as doing considerable damage to leaves stems and bunches of grapes in Egypt (Amin and Emam, 1996). A study of three grape varieties showed that infested plants were significantly shorter than uninfested plants and had increased number of internodes accompanied by shortening of internodes. Abnormal growth of leaves and stems of grapevines may have been due to the toxic salivary secretions excreted by the mealybug during feeding on the tissues (Amin et al, 1994; cited in Amin and Emam (1996).

Hosts

M. hirsutus is highly polyphagous: Ben-Dov (1994) records 98 host genera/species in 36 families; Meyerdirk and others (2001) record more than 200 genera of plants in 70 different families.
M. hirsutus is a well-known pest of cotton, hibiscus and many ornamentals (Ben-Dov, 1994). When it established in Grenada, it rapidly became a pest of food plants, ornamentals, weeds, fruit and forest trees (Persad and Khan, 2002). Grape (*Vitis vinifera*) is a host (Williams, 1996). Citrus (*Citrus* sp.), and several vegetable crops may be severely affected (Hodges, 2006).

Rosaceous hosts include *Prunus domestica*, *P. armeniaca*, *P. avium*, *P. campanulata*, *P. cerasifera*, *P. cerasus*, *P. laurocerasus*, *P. lusitanica*, *P. mahaleb*, *P. persica*, *P. serotina*, *P. serrulata*, *P. spinosa*, *Pyrus communis* (Hall, 1921), *Malus domestica* (as *Pyrus malus*) and *Rosa* spp. (ScaleNet, 2009).

Plant parts affected

Flowers, stems, leaves, fruit (CPC, 2007; Meyerdirk et al, 2001); roots and tubers (Meyerdirk et al, 2001).

Geographical distribution

M. hirsutus occurs in tropical and subtropical regions and extends into some temperate areas. It is generally accepted that it originated in southern Asia and it has been recorded from much of this region. It probably reached Egypt as early as 1908, and has now spread through much of Africa. In the Middle East it is known from as far north as Lebanon. In Australia it is known from Western Australia, Northern Territories and Queensland where the earliest records only date from 1959. *M. hirsutus* was introduced to Hawaii in the 1980s (Williams, 1996). It was first confirmed present in the Caribbean in 1994, in Grenada, and has quickly spread to other islands. It is now found in the Americas including California, Florida, and Mexico, Belize in Central America, and Guyana and Venezuela in South America (Hoy et al, 2006; Goolsby et al, 2002; Kairo et al, 2000; Williams, 1996).

M. hirsutus is present in China (Ben-Dov, 1994; Williams, 1996; ScaleNet, 2009) and has been recorded from Guangdong, Shanxi, Xizhang, Yunnan, and Hong Kong (CPC, 2007).

Hazard identification conclusion

M. hirsutus is present in China. It is not known to be in New Zealand. It has been recorded from *Pyrus* and is known to infest fruit, at least of other species. It is considered to be a potential hazard.

8.12.2 Risk assessment

Entry assessment

M. hirsutus is recorded as a tertiary pest of pears; it is rarely found on these hosts and never does any serious damage (Hall, 1921). Although *Pyrus* is not a primary host, the nymphs could be blown into pear orchards from any preferred hosts nearby. No information has been found on infestation of fruit of *Pyrus*. On grapevines, the young nymphs which are mobile tend to have a preference for young tender plant parts. However, eggs, nymphs and adults can be found on all plant parts including fruit. Females choose protected places for the whitish cottony eggsacks. The eggsack, which is attached to the host, also includes white wax which sticks to each egg, facilitating passive transport. The reddish pink nymphs and adults (about 2–3 mm long) are also covered in sticky white wax which is protective and helps them adhere to the host. The eggsacks, nymphs and adults tend to be very visible on the host (Meyerdirk et al, 2001). It is likely that most infested fruit would be detected and discarded during the harvest and packing processes. It is assumed that *M. hirsutus* would be able to survive the pathway from China to New Zealand.

Given that:

- the prevalence of *M. hirsutus* in pear orchards is likely to be very low;
- young growing parts of host plants are more likely to be infested than fruit;
- most infested fruit are likely to be detected and discarded during the harvest and packing processes;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of entry is considered to be negligible. *As a result the risk estimate for Maconellicoccus hirsutus is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *Maconellicoccus hirsutus* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

It is unknown how prevalent *M. hirsutus* is throughout the China pear growing regions. There is little published information on the species on pears.

8.13 *Nipaecoccus viridis – spherical mealybug*

Scientific name:	*Nipaecoccus viridis* (Newstead) (Hemiptera: Pseudococcidae)
Other relevant scientific names:	*Dactylopius perniciosus* Newstead and Willcocks, 1910; *Dactylopius vastator* Maskell, 1895; *Dactylopius viridis* Newstead, 1894; *Nipaecoccus vastator* (Maskell) Ferris, 1950; *Pseudococcus albizziae* (Maskell) Kirkaldy, 1902; *Pseudococcus filamentosus corymbatus* Green, 1922; *Pseudococcus perniciosus* Newstead, 1920; *Pseudococcus solitarius* Brain, 1915; *Pseudococcus vastator* (Maskell) Kirkaldy, 1902; *Pseudococcus viridis* (Newstead) Fernald, 1903; *Ripersia theae* Rutherford, 1915; *Trionymus sericeus* James, 1936
Common names:	spherical mealybug, hibiscus mealybug, karoo thorn mealybug

8.13.1 Hazard identification

New Zealand status

Nipaecoccus viridis is not known to be present in New Zealand. Not recorded in: ScaleNet (2009), PPIN (2008).

Biology

Nipaecoccus viridis is an important tropical and sub-tropical pest of numerous food, forage, fibre and ornamental crops (Sharaf and Meyerdirk, 1987). In Israel, it infests all parts of the citrus tree and excretes large quantities of honeydew which encourages sooty mould, appearance of irregular green spots on the fruit and malformed fruit which are rendered inexportable (Gross et al, 2000).

N. viridis has been reported to reproduce both sexually and parthenogenically (Sharaf and Meyerdirk, 1987). In the sexual type of reproduction the eggs are laid in an ovisac that is secreted under the body of the female a few days before the eggs are laid (Sharaf and Meyerdirk, 1987). These cotton masses go on increasing in size, partly on branches, shoots and twigs (upper and lower surfaces), and on fruits, especially attached at the base (Abdul-Rassoul, 1970). By the time the last eggs are laid the body of the female becomes raised and anchored to the host plant, giving reproducing *N. viridis* a nodular appearance (Sharaf and Meyerdirk, 1987). The life cycle depends on environmental conditions and the host. A female can lay about 600 eggs. The female dies soon after oviposition, which lasts from 21 to 37 days. First instar nymphs are less than 0.5 mm long and can be mobile. The nymphs congregate and feed in the vicinity of the ovisac, if it is in a suitable position, but move away otherwise. Males have five instars and have a development time of about 20 days whilst the females have four. *N. viridis* reproduces throughout the year with some retardation of development during the winter months. There are multiple overlapping generations (Sharaf and Meyerdirk, 1987).

On deciduous plants such as mulberry, populations peak in the autumn and leaves laden with eggs and crawlers fall to the ground, where they over-winter and become a source of infestation for the following year's growth. In contrast, *N. viridis* remains on *Citrus* plants in small numbers over the winter (Sharaf and Meyerdirk, 1987).

In Iraq, populations of *N. viridis* peak in May and October (Abdul-Rassoul, 1970). Significant positive correlations between population density and temperature, and negative correlations with relative humidity have been found. Females of *N. viridis* each laid 90–138 eggs, and the egg and nymphal stages lasted 10–13 and 31–43 days, respectively; overwintering took place as eggs, nymphs and adults (Jarjes et al, 1989).

In South African C*itrus* orchards, there are three generations of *N. viridis* per year. The September-October generation of mature females lays eggs that hatch during October-November. The crawlers migrate and settle mainly in protected areas, under the sepals of the fruitlets when they are pea-sized or larger. The second generation matures in November and lays eggs which hatch during December. The third generation of females matures in about March-April (CPC, 2007).

On citrus, *N. viridis* infests twigs, shoots, leaves, flower buds and fruit. It sucks the plant sap, causing curling and dwarfing of the terminal growth, abortion of flowers, yellowing of leaves and dropping of fruit (ScaleNet, 2009). It can also cause lumpy outgrowths near the stem end of fruit (CPC, 2007). Ghosh and Ghosh (1985) found that the artificial infestation of host plants with *Nipaecoccus viridis* resulted, in general, in arrestment of linear growth of the stems and petioles and great reduction and crumpling of the leaves.

Hosts

Nipaecoccus viridis is highly polyphagous (CPC, 2007). Hosts have been recorded in at least 45 plant families and 73 genera (ScaleNet, 2009; Sharaf and Meyerdirk, 1987). Many host plants are trees, including crops such as citrus and coffee (CPC, 2007). Families that contain a large number of host species are Euphorbiaceae, Leguminosae and Rutaceae (ScaleNet, 2009). It has been reported to cause damage in vineyards in Bangalore (Mani and Thontadarya, 1987). In India, *N. viridis* is a sporadic but often severe pest on jack fruit (*Artocarpus heterophyllus* (Mani and Krishnamoorthy, 1997). The severity of infestation varies between host species and between seasons (Abdul-Rassoul, 1970).

Major hosts are *Citrus* spp., *Coffea* sp. and *Gossypium* sp. (CPC, 2007). *Pyrus communis* has been recorded as a host in Iraq (Abdul-Rassoul, 1970) although only slight damage is caused (Sharaf and Meyerdirk, 1987). *Vitis vinifera* has also been recorded as a host in Iraq (Abdul-Rassoul, 1970).

Plant parts affected

Branches, twigs, fruit and leaves (Abdul-Rassoul, 1970); all plant parts of *Citrus* (ScaleNet, 2009).

Geographical distribution

Nipaecoccus viridis is widespread throughout the tropics and subtropics including Africa, parts of Central America, Oceania and Asia (ScaleNet, 2009). Because of the confusion of the taxonomic identification of *N. viridis* its distribution can not be precisely determined (Sharaf and Meyerdirk, 1987).

Within China, *N. viridis* has been recorded in Hunan, Hong Kong (ScaleNet, 2009).

Hazard identification conclusion

Nipaecoccus viridis has been recorded on *Pyrus communis*. It occurs in China, and not in New Zealand. It affects fruit of at least some hosts and is considered to be a potential hazard.

8.13.2 Risk assessment

Entry assessment

Nipaecoccus viridis has not been reported from the main temperate pear growing regions in China. In addition, there is little evidence that it severely infests *Pyrus*. This together with its tropical and sub-tropical distribution suggests that its prevalence in pear orchards is likely to be extremely low.

In Iraq it is reported to infest all parts of a host plant including the fruit. However, no reports have been found in the literature of it occurring on fruit of pears, and other than in the case of *Citrus* it appears to occur more commonly on leaves and twigs.

Although the nymphs and adults are tiny, they tend to congregate around the cottony egg sac which is expected to be readily detectable in the harvest and packing processes. Infested plants are likely to have sooty mould growing on honeydew on the fruit. Such fruit are likely to be discarded.

Given that:

- *N. viridis* is likely to have very low prevalence, if any, in the pear orchards of China;
- fruit of pears are less likely to be infested that other plant parts;
- infestation on fruit is likely to be associated with cottony egg sacs and be readily detectable in the pre-export process;

The likelihood of entry is considered to be negligible.

Risk estimation

Nipaecoccus viridis has a negligible likelihood of entry. *As a result the risk estimate for N. viridis is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *Nipaecoccus viridis* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a ‘regulated pest’. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

The distribution of *Nipaecoccus viridis* in China and its prevalence in pear orchards is uncertain. The frequency with which it infests mature pear fruit is not known.

8.14 *Parlatoria oleae – olive scale*

Scientific name: *Parlatoria oleae* (Colvée, 1880) (Hemiptera: Diaspididae)

Other relevant scientific names: *Diaspis oleae* Colvée, 1880; *Diaspis squamosus* Newstead and Theobald, 1904; *Parlatoria affinis* Newstead, 1897; *Parlatoria calianthina* Berlese and Leonardi, 1896; *Parlatoria judaica* Bodenheimer, 1924; *Parlatoria morrisoni* Bodenheimer, 1944

Common names: olive parlatoria scale, olive scale

8.14.1 Hazard identification

New Zealand status

Parlatoria oleae is not known to be present in New Zealand. Not recorded in: Charles and Henderson (2002), PPIN (2008).

Biology

Heavy infestations of *Parlatoria oleae* often result in an encrustation of the twigs and limbs of affected plants, and cause leaf wilting, yellowing and dieback; discoloured and distorted fruit and premature fruit drop and weakened or killed branches. The upper branches of the tree are usually more heavily infested than the lower branches, with the highest density occurring on the limbs and spurs of the host. Later generations settle on the fruit rather than the leaves. Infestations on fruit such as apples and peaches may result in a dark red spot around the feeding site (AEI, 2008).

The scale cover of the adult female is 1–2 mm diameter, circular to elliptical, white to very light grey with darker, subcentral to terminal exuviae and the body of the adult female is deep purple. The male scale cover is white, oblong, about 1 mm long, with a brownish-yellow terminal exuviae often marked with dark green, and the adult male is winged. The eggs and immature stages are pink to violet (AEI, 2008).

Reproduction is sexual. Each female produces an average of 90 eggs, although egg numbers are rather lower than this in central Europe. The development and number of eggs produced depends on temperature, humidity and host plant. There are two generations per year in California and the southern USA, but up to four generations per year in the Mediterranean region (AEI, 2008). In central Asia, *P. oleae* has two generations per year (ScaleNet, 2009).

P. oleae overwinters as fertilised adult females or second instar females on the bark. Its winter diapause is facultative (Kozar, 1990). In the autumn population in California, males represented about 80% of the population on the leaves, with the reverse true for those scales on the limbs (AEI, 2008).

The first instar crawlers are the dispersal phase, although they cannot walk far. Distribution over greater distances is by wind, animals, and by human transport of infested material (AEI, 2008).

Direct financial loss is incurred from this pest due to the marking and discoloration of smooth-skinned fruit such as plums, apricots and olives. It has been reported as a major agricultural pest in the USA; as one of the most important pests of apple in the Central Asia, the western Transcaucasus and Afghanistan; a serious pest of olives, primarily the table variety, throughout the Mediterranean region; a pest of olives, apples, pears and plums in the Middle East; a serious pest of fruit in Bulgaria and eastern Georgia and in Argentina it is abundant on olive and Rosaceae (AEI, 2008).

P. oleae was a very serious pest of olives and deciduous fruit crops in California until biological controls were successfully established (AEI, 2008).

It occurs very frequently even in orchards treated with chemicals (Kozar, 1990).

Hosts

The primary host of *Parlatoria oleae* is olive (*Olea europaea*) but it is also found infesting numerous fruit, nut and ornamental plant species. It has been collected from over 200 species of host plants in California, USA, and is reported to infest species in over 80 genera in central Europe. However, many of these host plants will not support the development of olive scale (CPC, 2007).

Major hosts: *Malus domestica*, *Olea europaea* subsp. *europaea*, *Pistacia vera*, *Prunus amygdalus*, *Prunus domestica*, *Prunus persica*, *Prunus salicina*, *Ribes uva-crispa*, *Rosa* sp., *Ziziphus jujuba* (CPC, 2007).

Pyrus communis, *Pyrus* sp. (ScaleNet, 2009); *Pyrus* sp. nr. *communis* (AQSIQ, 2007); *Pyrus* spp. (Chen, 2003).

Plant parts affected

The affected plant parts include the trunk and branches, leaves and fruit (AEI, 2008).

It has been recorded on fruit (Chen, 2003; Hill, 1987), and on the fruit of *Pyrus* species e.g. *P.* sp. nr. *communis* (Zhang et al, 2004; Chen, 2003); fruit of *Pyrus* spp. (Watson, 2008; Gill, 1997).

Geographical distribution

P. oleae is present in Africa, Europe, Asia, Central, North and South America. It is probably native to the area between the eastern Mediterranean and India. Although relatively restricted in its range within countries throughout Europe and the Middle East, it often occurs in very high abundance. It is now widespread in the Mediterranean and subtropical areas of the world; its distribution has not changed significantly for several decades. *P. oleae* has not been recorded from the Pacific Islands but is present in Australia (AEI, 2008).

P. oleae is recorded in China in Anhui, Fujian, Guangdong, Guangxi, Guizhou, Jiangsu, Jiangxi, Shaanxi, Sichuan, Xinjiang, Yunnan and Zhejiang (Hua, 2000).

Hazard identification conclusion

Parlatoria oleae is a pest of *Pyrus* species. It is noted as infesting the fruit of its hosts including *Pyrus* sp. nr. *communis*. It is present in China including some of the main pear growing regions. It is not present in New Zealand, and is considered to be a potential hazard.

8.14.2 Risk assessment

Entry assessment

Pyrus is a major host and fruit of hosts are commonly infested. Adult scales with or without eggs are the most likely life stage to be associated with mature fruit. The scales are small (up to 2 mm diameter), and might not be detected during the pre-export process. Fertilised females are the over-wintering stage and would be expected to survive shipment to New Zealand.

Given that:

- *Pyrus* is a major host and fruit of hosts are commonly infested;
- female scales with or without eggs could be present on pear fruit at harvest;
- scales are not easy to detect;
- adults are likely to survive transfer to New Zealand;

The likelihood of entry is considered to be moderate and therefore non-negligible.

Exposure assessment

Damaged or uneaten fruit and peel disposed of in New Zealand provides an exposure route for *P. oleae* entering on imported pears. Crawlers, hatching from eggs, or gravid females would need to be present on fruit and the infested fruit would need to be in close contact with a suitable host so that hatched crawlers could crawl or be blown to the host. The passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. Crawlers are susceptible to desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage (APHIS, 2007).

The wide host range of *P. oleae,* including many genera that are widely distributed in home gardens in New Zealand, increases the likelihood of any nearby tree being a suitable host.

Given that:

- crawlers can move short distances actively or long distances passively;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality;
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant;
- *P. oleae* has a wide host range and suitable hosts are widely distributed in New Zealand;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

P. oleae reproduces sexually, but the large number of eggs laid by the female in aggregation under the scale increases the likelihood of successful reproduction. The host range of *P. oleae* is relatively wide and favoured rosaceous hosts such as *Malus*, *Prunus* and *Rosa* species are well represented in New Zealand. Its global distribution includes European countries with temperate climates and it is assumed that establishment would be unlikely to be limited by the New Zealand climate.

Given that:

- *P. oleae* reproduces sexually, but features of its biology increase the likelihood of an individual finding a mate;
- climate is unlikely to be a barrier to establishment;
- multiple generations per year enable rapid population build up and *P. oleae* can easily be spread in association with transported plant material;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

As *P. oleae* is a significant pest of olives and deciduous fruit trees and has a wide host range on woody plants, it is likely to have economic effects on the commercial production of olives, apples, pears and stonefruit in New Zealand.

The potential economic impact within New Zealand is considered to be moderate.

Environmental consequences

About half the host families have representative species in the New Zealand flora including native species in the genera *Phormium, Hibiscus, Clematis, Rubus* and *Sophora*. Whilst the long term ecological effects on native plants are uncertain, it is likely there would be associated social and cultural impacts.

The potential environmental impacts within New Zealand are uncertain.

Human health consequences

There are no known human health impacts.

Risk estimation

Parlatoria oleae has a moderate likelihood of entry low likelihood of exposure and moderate likelihood of establishment. The potential economic impact within New Zealand is moderate. *As a result the risk estimate for P. oleae is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified*.

Assessment of uncertainty

Parlatoria oleae is not recorded in the available literature as infesting all pear species, however, as it is recorded from *Pyrus* sp. nr. *communis* in China and has a wide host range it is assumed that it is likely to infest other pear species.

8.14.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

P. oleae is widespread in China and has been recorded from Anhui, Fujian, Guangdong, Guangxi, Guizhou, Jiangsu, Jiangxi, Shaanxi, Sichuan, Xinjiang, Yunnan and Zhejiang. Therefore, pest-free areas are not likely to be a viable option.

Bagging of fruit

There is no evidence indicating that bags protect pear fruit from infestation. Fruit are bagged up to one month after fruit set (see section 2.2.3 and section 4.4). Crawlers may enter the bag between bag and stalk and they could access the fruit prior to bagging. Inspection of surrounding leaves and fruit when bags are changed would give prior warning of an infestation.

High pressure air blasting

Use of high pressure air guns in the pack houses would be expected to remove crawlers which are blown in the wind, but adults would be unaffected.

Phytosanitary inspection prior to export

The scale insects are likely to be visible on the fruit; however, since they are a few millimetres in diameter they could be missed if few are present.

Cold treatment

Since female scales over-winter in their native range, they are likely to be able to survive refrigerated shipment to New Zealand or other cold treatment. This is therefore not likely to be a viable option.

In-field management

P. oleae has been successfully treated in China with detergent at the end of February and spraying a mixed solution of water, wheat flour, soap and petroleum during the vegetative period (Liang et al, 1999). In experimental work in the field, methidathion, acetamiprid and beta-cypermethrin showed 85.5, 81.7 and 80.7% control at 15 days after application (Huang et al, 2004). The efficacy of this option is uncertain.

A combination of fruit bagging, air brushing and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

8.15 *Pinnaspis strachani – Hibiscus snow scale*

Scientific name: *Pinnaspis strachani* (Cooley, 1899) (Hemiptera: Diaspididae)
Other relevant scientific names: *Pinnaspis temporaria* Ferris, 1942
Common names: Hibiscus snow scale, cotton white scale, lesser snow scale, small snow scale

8.15.1 Hazard identification

Taxonomy

Pinnaspis strachani has been misidentified by a number of investigators (AEI, 2008; ScaleNet, 2009). In particular, specimens identified as *Chionaspis minor* Maskell from countries other than New Zealand have been found to be misidentifications of *P. strachani* (Williams and Watson, 1988; Henderson, 2001). *Chionaspis minor* is a junior synonym of *Pinnaspis dysoxyli* (Maskell), a species native to New Zealand that feeds on *Dysoxylum spectabile* (Henderson, 2001).

New Zealand status

Pinnaspis strachani is not known to be present in New Zealand. Not recorded in: Charles and Henderson (2002), PPIN (2008). Nakahara (1982) stated that it is present in New Zealand, possibly because it was erroneously thought to be synonymous with *Pinnaspis minor*, which he lists as a synonym, however, *P. minor* is not present in New Zealand either. Charles and Henderson (2002) state that this is a further case of mistaken identity and no other record of its presence in New Zealand has been found.

Biology

Pinnaspis strachani is a bisexual multivoltine species. Heavy infestations may cause discoloration and mummification of fruit, discoloration of leaves, wilting, potential premature leaf drop, and die-back of stems or even the entire plant (AEI, 2008).

The females undergo three development stages, while males have five stages. Reproduction is sexual. The female lays eggs beneath her scale then shrivels and dies post-oviposition (Fernández et al, 1993). After hatching, short range dispersal happens as crawlers search out places to settle and feed on the stems and leaves of the host (Beardsley and Gonzalez, 1975). They are mobile for a period ranging from minutes to days, but usually a few hours (Tenbrick et al, 2007). Males appear to settle near or adjacent to females (CPC, 2007) (accessed 09/02/2009). The second instar larvae lose their legs and become sessile. The species is mobile only during the crawler (first nymphal) stage and in the male adult. Males emerge from their armour at maturity, in the late afternoon, living only a few hours to mate. Females and feeding nymphs are attached to the plant by hair-like mouthparts (Tenbrick et al, 2007).

Development time for the males and females is approximately 23 and 45 days, respectively (Fernández et al, 1993), but this is dependant on temperature, humidity and rainfall (Beardsley and Gonzalez, 1975). Climatic conditions appear to influence the population density of this species, in addition to parasitoids and predators (CPC, 2007).

P. strachani has been recorded occurring in greenhouses in France and Hungary (Reiderne and Kozar, 1994; Germaine and Matile-Ferrero, 2005). This species is found mainly in tropical and subtropical regions so it is assumed it prefers warmer environments. It has been intercepted several times at the New Zealand border on coconut, bananas and curry leaves from tropical destinations (MAFBNZ, 2009).

Hosts

Pinnaspis strachani is a highly polyphagous species. A combined list of hosts from AEI, ScaleNet and CPC (2007) includes 238 genera from 85 families. Palms, Liliaceae and orchids are favoured hosts (AEI, 2008). It is an important pest of several crops, including *Citrus* (Williams and Watson, 1988). It infests glasshouse ornamentals in Hungary and Korea.

Both AEI and ScaleNet (2009) record *Pyrus* sp. as a host. Other hosts in the Rosaceae are *Prunus* sp. (AEI, 2008; CPC, 2007) and *Prunus persica* (ScaleNet, 2009).

Plant parts affected

Vegetative, flowering, fruiting and post-harvest plant parts are affected, leaves and fruit only occasionally (AEI, 2008).

Geographical distribution

Pinnaspis strachani is a cosmopolitan species in tropical and subtropical regions (AEI, 2008) e.g. Asia, Africa, southern USA, Central and parts of South America and Oceania (CPC, 2007). In Europe, it is restricted to glasshouses, e.g. in Italy, Germany, Hungary, USSR (former republic).

P. strachani is present in China in the provinces: Fujian, Guangdong, Hainan and Hong Kong (AEI, 2008). None of these are the main export pear growing provinces.

Hazard identification conclusion

Pinnaspis strachani has been recorded on *Pyrus* and infests the fruit of hosts, although there are no specific records on *Pyrus* fruit. It is not recorded from New Zealand and is considered a potential hazard.

8.15.2 Risk assessment

Entry assessment

P. strachani has not been recorded specifically from *Pyrus bretschneideri*, *P. pyrifolia* or *Pyrus* sp. nr. *communis* and *Pyrus* does not appear to be a preferred host. It has only been recorded from the most southern provinces of China, which are not the main pear growing areas. It is assumed that its prevalence in orchards growing pears for export will be low. Young growing parts of host plants appear to be more likely to be infested than fruit.

Scale insects are small and often inconspicuous. Heavy infestations of *P. strachani* cause mummification of fruit which would be expected to be detected and discarded during the harvest and packing processes. The fact that it has been intercepted on other commodities indicates that it may be overlooked. Females and feeding nymphs are attached to the plant by hair-like mouthparts (Tenbrick et al, 2007).

Given that:

- prevalence of *P. strachani* is likely to be low in orchards growing pears for export;
- it appears to prefer young growing parts of the plant rather than fruit;
- heavy infestations are likely to be detected;
- low infestations may go undetected;
- females and feeding nymphs are well-attached to the host;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Damaged or uneaten fruit and peel disposed of in New Zealand provides an exposure route for *P. strachani* entering on imported pears. The discarded fruit would need to stay in good enough condition to support the development of *P. strachani* to the point of having mobile life stages present after the fruit have been discarded. Male nymphs that complete development to adult on the imported fruit would have the capacity to disperse from discarded fruit if still alive by that time. Gravid females would need to be present on fruit and the infested fruit would need to be in close contact with a suitable host so that hatching crawlers could crawl or be blown to the host.

Crawlers are mobile for a period ranging from minutes to days, but usually a few hours (Tenbrick et al, 2007). They would be able to move shorts distances actively and long distances passively by wind or vectors. It is uncertain how far crawlers can actively disperse, but it is assumed that they would not be able to move far. In addition, the mainly tropical distribution of *P. strachani* suggests that the crawlers might only be mobile if the ambient temperature is sufficiently high and the humidity is appropriate (Tenbrick et al, 2007), and these conditions would depend on both geographic location and season in New Zealand. The passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. Crawlers are susceptible to extremes of temperature, desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage.

P. strachani is highly polyphagous so it is likely that there would be suitable host plants in the vicinity of discard sites.

Given that:

- the only mobile stages of *P. strachani* are first instar nymphs (crawlers) and short-lived adult males;
- crawlers can move short distances actively or long distances passively;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality;
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant;
- *P. strachani* is highly polyphagous, and acceptable hosts are widely available in modified habitats;

The likelihood of exposure is considered to be very low and therefore non-negligible.

Establishment assessment

P. strachani is widespread and polyphagous with a short lifecycle. Although there is no temperature tolerance data for the organism it is predominantly found in tropical areas or under glass (CPC, 2007). Where the accessed literature has referred to *P. strachani* in temperate European countries such as Hungary or France, it has been in relation to glasshouses. For China, accessed literature has referred only to it being present in Hong Kong and three southern provinces. *P. strachani* has been recorded as established in the southern United States. However, it is not clear that it is a problem or widespread in southern states other than Florida. In California, it is intercepted in shipments from Hawaii and Florida and is occasionally found in nurseries in Los Angeles (von Ellenreider, 2003). It is uncertain that it appears in other southern states. Therefore it seems likely that *P. strachani* would not survive the winter in New Zealand environment unless under glasshouse conditions. The likelihood for exposure to plants in commercial greenhouses in New Zealand is negligible because of protocols and practices that would be undertaken to protect commercial crops.

Given that:
- *P. strachani* is unlikely to survive the winter in New Zealand unless under glasshouse conditions;
- plants in commercial glasshouses are unlikely to be exposed to *P. strachani*

The likelihood of establishment is considered to be negligible.

Risk estimation

Pinnaspis strachani has a low likelihood of entry, a very low likelihood of exposure and negligible likelihood of establishment. *As a result the risk estimate for P. strachani is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *Pinnaspis strachani* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

There is limited information available about the biology of *P. strachani*. There is considerable uncertainty about the temperature tolerance and possibility for survival in New Zealand. In addition, misidentifications have made records of its distribution uncertain.

8.16 *Planococcus citri – citrus mealybug*

Scientific name: *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae)
Other relevant scientific names: *Coccus citri* (Risso); *Pseudococcus citri* (Risso)
Common names: citrus mealybug, grape mealybug, common mealybug

8.16.1 Hazard identification

New Zealand status

Planococcus citri is not known to be established in New Zealand. It was detected in a glasshouse in Auckland in May 2007 and containment/eradication at the infested site was managed under sections 52 and 53 of the Biosecurity Act 1993. *P. citri* is an unwanted organism under the Biosecurity Act 1993. It was previously detected in New Zealand in 1978. The incursion at that time was subject to an eradication order and was eradicated (PPIN, 2008).

Biology

Adult female *Planococcus citri* scales are orange-pink and covered in a powdery white wax, being oval, 1.6–3.2mm long and 1.0–2.0mm wide (Cox, 1987). The male has a single pair of wings and no mouthparts (CPC, 2007)

P. citri is oviparous, producing eggs two weeks after fertilisation into a fluffy posterior ovisac. Egg numbers vary: 150–200 (Cote-d'Ivoire), 20–250 (Ghana), 300 (on cocoa in Trinidad) and up to 500 (on *Citrus* in California). Incubation is 2–10 days (Le Pelley, 1968). The period from hatching to egg laying is approximately 5 weeks (CPC, 2007). Females have 3 instars before adulthood. Duration of the nymphal stages varies from 16 days in Trinidad to 32–38 days in Cote d'Ivoire and Ghana (Entwhistle, 1972).

In Australia 300–600 eggs are laid in 1–2 weeks, hatching in about 1 week. In Queensland and the Northern Territory there are at least 6 generations per year whereas in South Australia and Victoria there are about 3–4 generations per year. In late spring young *P. citri* move onto *Citrus* fruit settling under the calyx or between touching fruit. In Peru, *P. citri* overwinters in the nymphal or adult stage and has four generations in the year. In Morocco on citrus, it has six to eight overlapping generations annually (CPC, 2007).

Experiments by Arai (1996) concluded the lower developmental threshold temperatures and thermal constants of *P. citri* raised on *Citrus* were 7.7˚C and 401 degree days during the nymphal stage and 8.0˚C and 378 degree days during the preovipositional period. The insects move on a plant in response to soil temperature below 25°C and air relative humidity below 85%; they migrate preferentially to the roots but move to the aerial parts when these parameters increase (CPC, 2007). On coffee leaves under laboratory conditions females lived (egg hatch to adult death) about 115 days and males only 27 days (Martin and Mau, 2007).

One researcher found that males were rare and believed parthenogenesis might occur; others have found that males and females are produced in approximately equal numbers (CPC, 2007).

P. citri is reported as a serious pest, causing damage to various crops such as *Citrus*, grapes and mangoes, although crop loss is usually difficult to assess. It is the most injurious of the mealybugs on *Citrus* in the Mediterranean region. Most of the early Pacific reports on *P. citri* causing severe outbreaks should refer to *Planococcus minor*, with which it was confused (CPC, 2007).

P. citri feeding leads to wilting of the plants due to sap depletion. In Taiwan, infested immature coffee berries become deformed and drop to the ground. *P. citri* infestation also causes indirect damage from the development of sooty moulds on honeydew secreted by the mealybug (CPC, 2007).

P. citri vectors several viruses, such as Grapevine leafroll, corky bark, Kober stem grooving and LN33 stem grooving viruses, Dioscorea alata bacilliform virus and cocoa swollen shoot badnavirus (CPC, 2007). From the information currently available, none of these are recorded in association with *Pyrus* species. They are either present in New Zealand or not recorded from China.

Hosts

P. citri is polyphagous and occurs on a wide range of flowering plants (CPC, 2007).
Major hosts: *Citrus* spp., *Ziziphus mauritiana* (CPC, 2007).
Minor hosts: *Ananas comosus*, *Annona muricata*, *Annona squamosa*, *Cajanus cajan*, *Carica papaya*, *Codiaeum variegatum*, *Coffea* sp., *Coleus* sp., *Dioscorea* sp., *Eugenia* sp., *Gossypium* sp., *Lycopersicon esculentum*, *Macadamia integrifolia*, *Mangifera indica*, *Manihot esculenta*, *Musa* sp., *Nicotiana tabacum*, *Persea americana*, *Psidium guajava*, *Saccharum officinarum*, *Solanum* sp., *Solanum tuberosum*, *Theobroma cacao*, *Vitis vinifera*, *Xanthium strumarium* (CPC, 2007); *Pyrus communis* (ScaleNet, 2009).

Plant parts affected

P. citri feeds on fruit, leaves and shoots of *Citrus* (Meyerdirk et al, 1981).

Geographical distribution

Planococcus citri occurs almost worldwide, but appears to be absent from some South Pacific Islands. In southern Europe, northern America and southern Australia, it mainly occurs in greenhouses (CPC, 2007).

In China, it has been recorded in Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hong Kong, Hubei, Hunan, Jiangsu, Jiangxi, Sichuan, Taiwan, Yunnan and Zhejiang (CPC, 2007).

Hazard identification conclusion

Planococcus citri is present in China, particularly in the southern Provinces, and is not known to be present in New Zealand. It is associated with *Pyrus communis* and known to infest the fruit of *Citrus*, and is therefore considered a potential hazard in this analysis.

8.16.2 Risk assessment

Entry assessment

There is little evidence that *Pyrus* is a host of *Planococcus citri*. ScaleNet (2009) provides a list of hosts and gives Granara de Willink and others (1997) as the citation for *Pyrus communis*. There is no other evidence of this genus as a host plant. Xinjiang is the main province in which *P.* sp. nr. *communis* for export is grown. *P. citri* has not been reported from this province. It is not recorded as being associated with the fruit of *Pyrus*. The major hosts are *Citrus* species. It occurs under the calyx of *Citrus* fruits (Meyerdirk et al, 1981). It is assumed that its prevalence in orchards growing pears for export will be very low. On cocoa and coffee it causes young fruits to wilt or drop to the ground. The presence of sooty mould is also likely to result in any fruit that are infested being discarded during the harvest and packing process.

Given that:

- there is little evidence that *P. citri* infests *Pyrus* spp.;
- there is no evidence that it infests fruit of *Pyrus*;
- assuming that effects on *Pyrus* will be similar to those on other commodities, any fruit that may be infested are likely to either wilt or fall to the ground or be evident due to the presence of sooty mould;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Planococcus citri* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for P. citri is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *Plannococcus citri* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a ‘regulated pest’. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

The status of *Pyrus* fruit as a host for *Planococcus citri* is uncertain. If further evidence becomes available this assessment may need to be revised.

8.17 *Planococcus kraunhiae – Japanese mealybug*

Scientific name: *Planococcus kraunhiae* (Kuwana, 1902) (Hemiptera: Pseudococcidae)

Other relevant scientific names: *Dactylopius kraunhiae* Kuwana, 1902; *Planococcus kraunhiae* Ferris, 1950; *Planococcus siakwanensis* Borchsenius, 1962; *Pseudococcus kraunhiae* Fernald, 1903

Common name: Japanese mealybug

8.17.1 Hazard identification

New Zealand status

Planococcus kraunhiae is not known to be present in New Zealand. Not recorded in: ScaleNet (2009), PPIN (2008).

Biology

In Japan, there are three generations of *Planococcus kraunhiae*, on persimmon each year. The first instar nymphs appear in June and August. Nymphs overwinter under the tree bark, and from late April to early May the overwintering nymphs move to the top of shoots (Morishita, 2005a).

In laboratory studies, the developmental period from egg to adult oviposition was 65 days at 20°C and 46 days at 24°C. The total number of eggs per female was 588 at 20°C and 965 at 24°C. Adult longevity of females at 20°C and 24°C was 32 days and 26 days, respectively (Narai and Murai, 2002).

Hosts

Diospyros kaki (persimmon) (Morishita, 2006; CPC, 2007); *Pyrus ussuriensis* (ScaleNet, 2009).

ScaleNet (2009) gives a list of host species in 24 plant families. Most of these families contain only one recorded host plant. It is likely that many of these hosts are incorrect and may result from the time when *P. kraunhiae* was thought to be a synonym of *P. citri*, which is highly polyphagous. Recent publications refer mainly to persimmon as a host.

Park and Hong (1992) describe *P. kraunhiae* feeding on pears (*P*. sp. nr. *communis* variety Jangsliplang) in Korea.

Plant parts affected

Bark, shoots (Morishita, 2005a); fruit of persimmon, under the calyx (Morishita, 2005b); pear fruit (Park and Hong, 1992).

Geographical distribution

Common in China, Japan and Korea, and known in the USA (Williams, 2004). Philippines, Taiwan (ScaleNet, 2009).

Hazard identification conclusion

Planococcus kraunhiae has been recorded on *Pyrus* is present in China, and is not present in New Zealand. It is associated with fruit and is considered a potential hazard.

8.17.2 Risk assessment

Entry assessment

No information has been found on the distribution of *P. kraunhiae* in China. In a survey in Korea in 1990–91, *Planococcus kraunhiae, Pseudococcus comstocki* and *Crisicoccus matsumotoi* were collected from bagged pears. *P. kraunhiae* accounted for 81% of the insects collected. The density of the scales on the fruit began to increase from mid-June and peaked in mid-July (with 48% damage), mid-August (with 51% damage) and early October. Assuming a similar pattern occurs in China, *P. kraunhiae* would be expected to be present on fruit at harvest. Assuming three generations per year in China, eggs, nymphs and adults are likely to be present at the time of harvest.

Mealybugs are small, and early instars can be inconspicuous. Most stages are firmly attached to their host by their piercing mouthparts. They also tend to be present in cryptic areas, such as around the calyx (Morishita, 2005b; Park and Hong, 1992) and may go unnoticed during the harvest and packing processes. No records have been found of *P. kraunhiae* on *Pyrus pyrifolia and P. bretschneideri,* neither of which have persistant calyces (Chapter 2). If it is associated with these species, the absence of a persistant calyx would be expected to further reduce the likelihood of entry.

Given that:
- the distribution of *P. kraunhiae* in China, and its association with *Pyrus pyrifolia and P. bretschneideri,*is not known;
- eggs, nymphs and adults could be present on pear fruit at harvest;
- mealybug life-stages are small and not easy to detect;
- *Pyrus pyrifolia and P. bretschneideri* do not have persistant calyces and therefore fewer hiding places;

The likelihood of entry is considered to be low and therefore non-negligible, at least for P. sp. nr. *communis.*

Exposure assessment

Following post-border distribution and disposal of fruit (either whole or remains), mealybugs need to disperse and locate suitable hosts. The mobile crawler is the primary dispersal stage, and can move short distances actively or long distances passively. Crawlers are susceptible to extremes of temperature, desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage. Field experiments showed that mealybugs actively moved a maximum of between 47 and 90 cm away from the original point of infestation. Overall, mealybugs showed little tendency to disperse away from the point of release (Grasswitz and James, 2008). Moreover, the passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. These results indicate that movement of mealybugs by walking is likely to be extremely slow. First instars can be passively dispersed via wind currents. Some were shown to disperse as far as 8 metres, but overall there was a rapid drop-off in dispersal with increasing distance from the source plants after three metres (Grasswitz and James, 2008).

Unlike armoured scale insects, female mealybug nymphs and adults are able to move limited distances at least. Bartlett (1978) recorded female *P. longispinus* moving to branches and tree trunks before oviposition, and James (1937) reported that females moved intermittently during the oviposition period, sometimes ceasing to feed and leaving the host plant altogether.
Some mealybugs may be carried to new host plants by ants (Beardsley et al, 1982). Two ant species known to farm mealybugs are the bigheaded ant, *Pheidole megacephala*, and the Argentine ant, *Linepithema humile*, both present in New Zealand (Berry, 2007).

The reported range of hosts for *P. kraunhiae* includes *Pyrus* spp. and several ornamentals such as wisteria and magnolia that are likely to occur patchily in domestic gardens.

Given that:

- nymphs and adults are mobile to some degree;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant
- Suitable hosts occur in New Zealand but are patchily distributed

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

A mated female or immatures of both sexes need to be present to establish a reproductive population. For permanent establishment, male mealybugs must be able to locate females and conditions must be suitable for mating and egg laying to occur. The tendency for *P. kraunhiae* to congregate around the calyx of infested fruit may increase the likelihood of successful reproduction.

Little is known about the eco-climatic tolerances of *P. kraunhiae.* Given its distribution in parts of the world with temperate climates, it is assumed that climate would not be a barrier to establishment, at least in parts of New Zealand.

Given that:

- *P. kraunhiae* reproduces sexually, but features of its biology increase the likelihood of an individual finding a mate;
- climate is unlikely to be a barrier to establishment in at least some areas;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

Hosts of *P. kraunhiae* available in New Zealand include *Pyrus communis* and *P. pyrifolia* and its crosses. The size of the New Zealand pear industry (*Pyrus communis*) was 412 ha in 2008 (Pipfruit New Zealand, 2008). There is no recent available information on the size of the nashi industry in New Zealand. In 2002, there were 119 ha of nashi (*Pyrus*

pyrifolia) grown commercially in New Zealand (Statistics New Zealand, 2002). This is likely to have declined in line with the European pear industry, which has more than halved since 2002 (from 965 ha in 2002 to 412 ha in 2008) (Pipfruit New Zealand, 2008). Persimmon appears to be a major host. Commercial cultivation of persimmon in New Zealand is limited to the warmer parts of the North Island
The potential economic impact within New Zealand is considered to be low.

Environmental consequences

P. kraunhiae is polyphagous, but it is very difficult to predict what plants it will feed on when introduced to a new environment. Beever et al. (2007) suggest that, in terms of risk to native flora, and based on known attacks on native plants by exotic species present in New Zealand, sap-sucking hemipterans such as mealybugs are a relatively high risk group, particularly polyphagous species. This review was based on factors affecting the likelihood of this group of organisms becoming established, not just their anticipated impacts. *Pseudococcus longispinus,* a related species established in New Zealand, is known to attack native plant species (Spiller and Wise, 1982), but the scale of these impacts is relatively small. The displacement of native mealybug species is another possible consequence of establishment. Whilst mealybugs may be more likely than some other plant pests to have negative impacts on native flora, the scale of impacts on native species populations is likely to be low.
The potential environmental impact within New Zealand is considered to be uncertain.

Human health consequences

There are no known human health consequences.

Risk estimation

The likelihood of *Planococcus kraunhiae* entering New Zealand with *Pyrus* fresh produce from China is low and the likelihood of exposure and of establishment is low. The potential economic consequences are considered to be low. *As a result the risk estimate for P. kraunhiae is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified*.

Assessment of uncertainty

The prevalence and distribution of *Planococcus kraunhiae* in China is unknown.

8.17.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

The distribution of *P. kraunhiae* in China is not known. It is unlikely that pest free area status will be a viable option.

Bagging of fruit

Individual bagging of fruit is known to be a factor in infestations of this species on *Pyrus* fruit in Korea. Bagging is not considered a viable option.

Phytosanitary inspection prior to export

Mealybugs are small but can be conspicuous due to their bright white colour and powdery appearance. Their tendency to frequent the calyx can make them difficult to detect.

Cold treatment

The efficacy of this treatment is not known.

Airbrushing

Hot water dip of pears followed by brushing reduces levels of infestation of *Pseudococcus comstocki* by about half. Organisms deep within the calyx are particularly difficult to remove (Agnello et al, 1992). *P. kraunhiae* is also reported to be concentrated at the calyx end and this is unlikely to be an effective option.

8.18 *Pseudococcus comstocki – comstock mealybug*

Scientific name: *Pseudococcus comstocki* (Kuwana, 1902) (Hemiptera: Pseudococcidae)
Other relevant scientific names: *Dactylopius comstocki* Kuwana, 1902
Common names: comstock mealybug, japanese mealybug

8.18.1 Hazard identification

New Zealand status

Pseudococcus comstocki is not known to be present in New Zealand. New Zealand records of *P. comstocki* have been demonstrated to be misidentifications of *P. calceolariae* (Cox, 1977; Cox, 1987; CPC, 2007).

Biology

Pseudococcus comstocki is occasionally a serious pest in apple, pear and citrus orchards. It also damages several ornamental and shade trees. Damage can include necroses, premature leaf drop or gall-like formations occurring at the feeding sites, and may predispose the tree to disease-causing organisms or result in reduced vigour (CPC, 2007).

P. comstocki injures the plant by extracting large quantities of sap and producing honeydew that serves as a substrate for the development of sooty mould, which prevents photosynthesis. It can damage the fruit by spotting and producing a change in the fruit skin texture. Feeding activity can stimulate the growth of gall-like formations on the bark and near the leaf veins (CPC, 2007).

Eggs are laid in a white, waxy sac behind the female's abdomen. On hatching, the immatures begin feeding and produce a thick coat of white powdery wax. Seventeen pairs of long wax filaments are segmentally arranged around the body, increasing in length from anterior to posterior. The pinkish females may be up to 4 mm long. The newly emerged adult males have one pair of wings, well-developed antennae and legs, and a pair of posterior waxy filaments about the length of the body (CPC, 2007).

In Hebei, *P. comstocki* has three generations per year. The crawler stage of the first generation is in late April, the second generation in early July and the third generation in early-mid August (Zheng, 2006).

In recent years, *P. comstocki* has become an important pest for apple orchards in China (Liu, 2004). Observations from an apple orchard in Shandong where all the fruit on the trees was bagged showed that over 50% of the bagged fruit could be infected with *P. comstocki*. The eggs over-winter under the bark or in the soil near the trunk (Huang et al, 2005; Liu, 2004). The eggs hatch from late March to late April, and the nymphs attack the tender tissue of the tree or feed on wounds to the tree (Huang et al, 2005). Adults of subsequent generations lay eggs on the tree, in the bags or on the ground amongst leaves or rocks (Huang et al, 2005). Reports of the number of eggs produced vary from 50–400 (Huang et al, 2005; Liu, 2004; Zheng, 2006). The nymphs of the second and third generations enter the bags and attack the fruit (Liu, 2004). *P. comstocki* primarily attacks the calyx end of the fruit, but also the stem end and elsewhere on the fruit. It causes black spots and white powder on the surface of the fruit (Huang et al, 2005).

In Hebei, fruit quality of *Pyrus pyrifolia* under bagged culture is seriously damaged by *P. comstocki* causing the fruit surface to form russet scars. It mainly attacks the fruit at the calyx end (Zheng, 2006). Similarly bagged fruit of *P.* sp. nr. *communis* is damaged by *P. comstocki* (Park and Hong, 1992).

P. comstocki was first reported in New York in 1918, but did not become a pest of pears until 1987–1989 when growers of pears for processing experienced severe losses due to infestation of *P. comstocki* at the calyx end of the fruits at harvest (Agnello et al, 1992).

Hosts

Major hosts: *Citrus limon*, *Coffea* sp., *Ficus carica*, *Malus domestica*, *Morus* sp., *Musa* sp., *Prunus* spp., *Punica granatum* (CPC, 2007); *Pyrus pyrifolia* (CPC, 2007; ScaleNet, 2009; Zheng, 2006), *Pyrus communis* (ScaleNet, 2009), *P.* sp. nr. *communis* (Park and Hong, 1992), *P. pyrifolia* (AQSIQ, 2007; Zheng, 2006) and *P. bretschneideri* (AQSIQ, 2007).

P. comstocki damages several agricultural crops including banana, peach, pear, lemon, apricot, cherry, catalpa and mulberry. It is known to infest over 65 host plants in California, USA, and over 300 plant species in Turkmenistan (CPC, 2007). ScaleNet (2009) records hosts of *P. comstocki* in 40 plant families.

Plant parts affected

Pyrus fruit (PPIN, 2008; Zheng, 2006); fruit, leaves (White et al, 1990). “On the aerial parts of the host plant” (ScaleNet, 2009); fruit, leaves, bark (CPC, 2007); branches, shoots, leaves and young fruit of apple (Li et al, 2004).

Geographical distribution

P. comstocki is a widespread species and is believed to be of Asian origin. Due to earlier misidentifications, literature records before 1961 should be regarded as suspect unless supported by authoritatively identified specimens.

Africa: Saint Helena (CPC, 2007).
Asia: Armenia, Azerbaijan, Cambodia (CPC, 2007); China (CPC, 2007; AQSIQ, 2007); Georgia (Republic), Japan, Kazakhstan, Korea (DPR), Korea (Republic of), Kyrgyzstan, Sri Lanka, Tajikistan, Thailand, Turkmenistan, Uzbekistan, Vietnam (CPC, 2007).
Europe: Moldova, Portugal, Russian Federation, Ukraine (CPC, 2007).
North America: Canada, Mexico, USA (CPC, 2007).
South America: Argentina (CPC, 2007).

Within China, *P. comstocki* has been recorded from Hebei (Zheng, 2006); Fujian, Guangdong, Hunan, Xizhang, Zhejiang, Heilongiang, Nei Mongol, Liaoning, Shandong, Shanxi, Hebei, Hubei, Jiangsu, Jianxi, Guangxi, Guizhou, Sichuan, Yunan (Hua, 2008), Henan (Liu, 2004), Shandong (Huang et al, 2005).

Hazard identification conclusion

Pseudococcus comstocki is present in China and is not known to be present in New Zealand. It is associated with *Pyrus* sp. nr. *communis*, *P. pyrifolia* and *P. bretschneideri* and is known to infest fruit, and is therefore considered a potential hazard in this analysis.

8.18.2 Risk assessment

Entry assessment

P. comstocki is widespread in China and pears are one of its main hosts. In China, second and third generation nymphs of *P. comstocki* enter the bags covering apples and attack the fruit. Similarly, in a study in Korea, paper bags were used to protect developing fruit of *Pyrus pyrifolia*. Fruit in these bags were more prone to infestation by *P. comstocki* than unbagged fruit (Kim et al, 1988). Adults or nymphs could be present on fruit at the time of harvest. Over-wintering eggs are laid in bark or in the soil and so are unlikely to be present.

The prevalence of *P. comstocki* in pear orchards will depend to some extent on the abundance of natural enemies. One study found that the predator *Cryptolaemus montrouzieri* reduced *P. comstocki* egg masses and immatures by 75 and 91%, and number of *P. comstocki* per leaf by 88% in China (Dong, 1993).

Mealybugs are small, and early instars can be inconspicuous; mature *P. comstocki* are 4 mm in length, pinkish and are uniformly covered with a white powdery wax. Most stages (except eggs, crawlers and adult males) are firmly attached to their host by their piercing mouthparts. They also tend to be present in cryptic areas, such as the stem and calyx ends of the fruit, and may go unnoticed during the harvest and packing processes.

There are numerous records of species of Pseudococcidae being intercepted on pears at the New Zealand border, including seven instances on *Pyrus bretschneideri* from China. These included juveniles and adults and most were alive (MAFBNZ, 2009).

Given that:

- *P. comstocki* is widespread in China and pears are one of its main hosts;
- adults or nymphs are likely to be present on fruit at the time of harvest;
- the size and location of these lifestages mean that they may not be detected and there have been interceptions of pseudococcids on *P. bretschneideri* at the New Zealand border;

The likelihood of entry is considered to be high and therefore non-negligible.

Exposure assessment

The optimal temperature for development of *P. comstocki* has been found to be 25°C (Jeon et al, 2003). Reproduction, survival and longevity are greatest at 22–26°C and lowest at 30°C (Heidari, 1999), and the low development threshold temperature is estimated as about 12°C (Jeon et al, 1996). Development would not occur in transit, but may resume on arrival in New Zealand.

Following post-border distribution and disposal of fruit (either whole or remains), mealybugs need to disperse and locate suitable hosts. The potential for dispersal depends on the life stage and sex: adult males are the only winged forms, but they are short lived and some data suggests they are not important in dispersal (Lo et al, 2006). The mobile crawler is the primary dispersal stage, and can move short distances actively or long distances passively. Crawlers are susceptible to extremes of temperature, desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage. Field experiments showed that mealybugs actively moved a maximum of between 47 and 90 cm away from the original point of infestation. Overall, mealybugs showed little tendency to disperse away from the point of release (Grasswitz and James, 2008). Moreover, the passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. These results indicate that movement of mealybugs by walking is likely to be extremely slow. First instars can be passively dispersed via wind currents. Some were shown to disperse as far as 8 metres, but overall there was a rapid drop-off in dispersal with increasing distance from the source plants after three metres (Grasswitz and James, 2008).

Unlike armoured scale insects, female mealybug nymphs and adults are able to move limited distances at least. Bartlett (1978) recorded female *P. longispinus* moving to branches and tree trunks before oviposition, and James (1937) reported that females moved intermittently during the oviposition period, sometimes ceasing to feed and leaving the host plant altogether. Some mealybugs may be carried to new host plants by ants (Beardsley et al, 1982). Two ant species known to farm mealybugs are the bigheaded ant, *Pheidole megacephala*, and the Argentine ant, *Linepithema humile*, both present in New Zealand (Berry, 2007).

P. comstocki is polyphagous, and suitable host species are widely distributed throughout New Zealand.

Given that:

- crawlers can move short distances actively or long distances passively;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant
- adults can move at least short distances to find suitable egg laying sites;
- *P. comstocki* is polyphagous, and suitable host species are widely distributed;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

Pseudococcus comstocki reproduces sexually, so a mated female or immatures of both sexes need to be present to establish a reproductive population. For permanent establishment, male mealybugs must be able to locate females and conditions must be suitable for mating and egg laying to occur. Males are non-feeding and live short periods of time, from one to several days. The short life span of males combined with their limited dispersal ability means that potential mates must be located nearby for males to find them and mate successfully. This likelihood is considered to be higher for mealybugs than for many other insects, due to their tendency to have an aggregated or clumped spatial distribution. Yamamura and Katsumata (1999) referred to this type of pest as gregarious, and considered them to have a higher probability of introduction into new areas via trade, due to the heightened likelihood of their locating a mate.

Despite their limited dispersal ability, the high reproductive capacity of mealybugs (Williams and Watson, 1988) means that a founding population could quickly increase in number and disperse to other nearby hosts. *P. comstocki* is established in parts of the world with climates similar to that in many parts of New Zealand.

Given that:

- individuals of opposite sexes are required for sexual reproduction;
- mealybugs have a clumped distribution which will increase the opportunities for finding a mate;
- hosts are widely distributed and climatic conditions are unlikely to be a barrier to establishment in New Zealand;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

The most obvious damage caused by *P. comstocki* is the presence of sooty mould on secreted honeydew which prevents photosynthesis. It can also damage the fruit by spotting and producing a change in the fruit skin texture. Feeding activity can stimulate the growth of gall-like formations on the bark and near the leaf veins (CPC, 2007). Indirect consequences of establishment could include an increase in pest control costs and/or disruption of existing control programmes, particularly those based on Integrated Pest Management. *P. comstocki* is a pest of a number of crops grown commercially in New Zealand including apples, stonefruit and lemons as well as pears. The presence of *P. comstocki* in commercial orchards may limit market access to overseas markets which are free of the mealybug.
The potential economic impact within New Zealand is considered to be moderate

Environmental consequences

P. comstocki is polyphagous, but it is very difficult to predict what plants it will feed on when introduced to a new environment. Beever et al. (2007) suggest that, in terms of risk to native flora, and based on known attacks on native plants by exotic species present in New Zealand, sap-sucking hemipterans such as mealybugs are a relatively high risk group, particularly polyphagous species. This review was based on factors affecting the likelihood of this group of organisms becoming established, not just their anticipated impacts. *Pseudococcus longispinus*, a related species established in New Zealand, is known to attack native plant species (Spiller and Wise, 1982), but the scale of these impacts is relatively small. The displacement of native mealybug species is another possible consequence of establishment. Whilst mealybugs may be more likely than some other plant pests to have negative impacts on native flora, the scale of impacts on native species populations is likely to be low.
The potential environmental impact within New Zealand is uncertain.

Human health consequences

There are no known human health consequences.

Risk estimation

Pseudococcus comstocki has a high likelihood of entry, low likelihood of exposure and moderate likelihood of establishment in New Zealand. The economic impact is likely to be moderate and the environmental impact uncertain. *As a result the risk estimate for P. comstocki is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There is little information available on the likelihood of crawlers successfully dispersing to a new host from a source which is not a whole plant, such as a piece of fruit. The ability of nymphs and adults to survive four weeks at 0–1°C is also unknown.

8.18.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

Pseudococcus comstocki is widespread in China and pest-free area status is unlikely to be a viable option. However no records have been found for its presence in Xinjiang, the main growing area for pears for export of *Pyrus* sp. nr. *communis* and pest free area status may be an option for these if the distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

Bagging of fruit

Individual bagging of fruit is known to increase infestations of this species on *Pyrus* fruit. In Hebei, fruit quality of *Pyrus pyrifolia* under bagged culture is seriously damaged by this mealybug. Bagging is not considered a viable option.

Phytosanitary inspection prior to export

P. comstocki are small but can be conspicuous due to their colour and powdery appearance. The mealybug secretions cause the formation of grey-black moulds on the fruit skin, making infestations more obvious (Li et al, 2004). Their tendency to frequent the calyx can make them difficult to detect.

Cold treatment

Nymphs and adults on pears held at 2°C for up to two weeks remained viable (Agnello et al, 1992). This is unlikely to be a viable option.

Airbrushing

Hot water dip of pears followed by brushing, reduced levels of infestation by about half. Organisms deep within the calyx were particularly difficult to remove (Agnello et al, 1992). This is unlikely to be a viable option.

Ethyl formate fumigation

Ethyl formate is a naturally occurring component in fruit with insecticidal properties that has been used as a fumigant for stored products. A study on table grapes found that fumigation with ethyl formate in normal air gives good control of *P. maritimus*. The lethal concentration of ethyl formate that kills 99% of tested mealybugs was 4.85% for eggs (9862 tested), 0.82% for crawlers (10 888 tested) and 1.79% for adults (787 tested). Adding 10% CO_2 significantly increased the efficacy of the treatment to an LC_{99} of 3.48% for eggs (8175 tested), 0.07% for crawlers (10 058 tested) and 1.29% for adults (723 tested) (Simpson et al, 2007). Bartlett pears tested for one hour at room temperature had a maximum tolerance dose of 3.2%. Doses in excess of this caused skin browning (Mitcham, 2005). Since eggs are unlikely to be associated with fruit, phytotoxicity appears unlikely to be a problem. Its efficacy against *P. comstocki* is not known, but it is an option that warrants further investigation.

In-field management

CPC (2007) reported that acceptable control of *P. comstocki* may be obtained by implementing one or two chemical applications timed to coincide with each generation of immatures. In China, Liu (2004) found that on bagged apples, *P. comstocki* was controlled by spraying 1500x dilution solution of 40% Lorsban emulsion or 1500x dilution of 52.25% Nurelle-D505 emulsion in mid- to late May. Zheng (2006) reported control by a pre-bagging spray of 300x solution of 30% Dursban watery emulsion and a post-bagging spray of 1000x solution of 3% Acelamiprid. The parasitoid *Cryptolaemus montrouzieri* has been found to reduce *P. comstocki* egg masses and immatures by 75 and 91.2%, and number of *P. comstocki* per leaf by 87.9% in China (Dong, 1993). In-field control may be an option if efficacy can be demonstrated for a particular regime.

8.19 *Pseudococcus maritimus – ocean mealybug*

Scientific name: *Pseudococcus maritimus* (Ehrhorn, 1900) (Hemiptera: Pseudococcidae)

Other relevant scientific names: *Dactylopius maritimus* Ehrhorn, 1900; *Pseudococcus bakeri* Essig, 1910; *Pseudococcus omniverae* Hollinger, 1917

Common names: grape mealybug, ocean mealybug

8.19.1 Hazard identification

New Zealand status

Pseudococcus maritimus is not known to be present in New Zealand. Not recorded in: CPC (2007), ScaleNet (2009), PPIN (2008). Cox (1977) noted that previous records of this species from New Zealand were based on misidentifications.

Biology

Pseudococcus maritimus is a polyphagous species, reported in California mainly as a pest of grape, pear and apricot (ScaleNet, 2009). It overwinters as eggs or crawlers within the loose cottony egg sac under bark scales, in other sheltered places on trees, or at the bases of tree (biology is according to Beers and others (1993) unless stated otherwise). In Washington, there is one full and a partial second generation each year. Some eggs laid by the first generation hatch during the summer and others overwinter. Some second generation crawlers also overwinter. In California, it develops two annual generations, and overwintering takes place in the ovisac or as first instar crawlers. Reproduction is sexual. Feeding is primarily on leaves. Adult females migrate to the trunk for oviposition (ScaleNet, 2009).

In addition to having a wide known host range, *P. maritimus* is able to develop new host strains allowing it to adapt to more hosts. Adaptations may include different development rates and numbers of generations per year (Beers et al, 1993).

In Xinjiang, China, *P. maritimus* has three generations on grapevine annually. The nymph hides in the soil, under bark and in cracks to overwinter. The overwintering nymphs begin to damage grapes in mid-March and overwintering female adults lay eggs from late-April to early-May (Abudujapa and Sun, 2007).

When reared on potato sprouts at ca. 24°C, the female mealybug had three larval instars while the male had four (Ben-Dov et al, 2009). Average number of eggs produced was 57, with larger females producing more eggs than smaller females. Mating was necessary for egg production. Trapping experiments in vineyards suggest that mature virgin female grape mealybugs produce a male attractant (Grimes and Cone, 1985; Ben-Dov et al, 2009).

Hosts

Pseudococcus maritimus is polyphagous, with host plants in at least 42 families (ScaleNet, 2009); Pyrus communis is reported as a host by BenDov (1994); Smith et al. (2006); Beers et al. (2003); Xie (1982); Hua (2000); Scalenet and CPC. Beers et al. (2003) state since the 1970s *P. maritimus* has become an increasingly severe pest of pear and apple in the USA.

Plant parts affected

P. maritimus is found mainly on leaves and under rough bark on trunks (ScaleNet, 2009). However, it has also been recorded on fruit in grape clusters (Grimes and Cone, 1985) and has been intercepted at the New Zealand border on apricot fruit from the USA (1997) and in 2005 on pear fruit from the USA (MAFBNZ, 2009).

Geographical distribution

Asia: China:Xinjiang, Shandong, Guangdong, Guanxi, Jiangsu, Fujian, (Abudujapa and Sun, 2007; Hua, 2000); Indonesia (ScaleNet, 2009).
Europe: Armenia, Poland (ScaleNet, 2008); Hungary, Netherlands (CPC, 2007).
North America: Bermuda, Canada, Mexico, Puerto Rico, United States of America (ScaleNet, 2009).
Central America: Guatemala (ScaleNet, 2009).
South America: Argentina, Brazil, Chile, Colombia, French Guiana (ScaleNet, 2009).

Hazard identification conclusion

Pseudococcus maritimus is present in Xinjiang Province, China and is not known to be present in New Zealand. It is associated with *Pyrus communis* and known to infest fruit, and is therefore considered a potential hazard in this analysis.

8.19.2 Risk assessment

Entry assessment

Adult females generally migrate to the trunk for oviposition and eggs are unlikely to be associated with the fruit. Mealybugs are small, and early instars can be inconspicuous. The young crawlers are orange. Mature mealybugs are 5 mm in length with dark, purple-gray bodies that are uniformly covered with a white powdery wax (University of California, 2009a).

Most stages (except eggs, crawlers and adult males) are firmly attached to their host by their piercing mouthparts. They also tend to be present in cryptic areas, such as the stem end of the fruit, and may go unnoticed in inspections. *P. maritimus* is generally associated with leaves and bark, but occasionally feeds in the calyx end of maturing fruit, which may become soft as the pear ripens (University of California, 2008). In California, *P. maritimus* contaminates table grapes with one or more of the following: the cottony egg sac, eggs, immature larvae, adults, honeydew, sooty mould growing on the honeydew. In severe cases fruit will be unsightly, difficult or impossible to process and will need to be discarded (Flaherty et al, 1982).

Live adults of this species have been intercepted twice at the New Zealand border on apricots and on pear fruit from the USA.

Given that:

- pears are one of the main hosts of *P. maritimus*, but it is not generally associated with the fruit;
- adults or nymphs are likely to be present on fruit at the time of harvest;

- the size and location of these lifestages mean that they may not be detected and there have been interceptions of this species on pears at the New Zealand border;

The likelihood of entry is considered to be moderate and therefore non-negligible, at least for P. sp. nr. *communis.*

Exposure assessment

Following post-border distribution and disposal of fruit (either whole or remains), mealybugs need to disperse and locate suitable hosts. The potential for dispersal depends on the life stage and sex: adult males are the only winged forms, but they are short-lived and some data suggests they are not important in dispersal (Lo et al, 2006). Female mealybug nymphs and adults have some limited mobility (e.g., Bartlett (1978)).

The mobile crawler is the primary dispersal stage, and can move short distances actively or long distances passively (Bartlett, 1978; James, 1937). Field experiments showed that mealybugs actively moved a maximum of between 47 and 90 cm away from the original point of infestation. Overall, mealybugs showed little tendency to disperse away from the point of release (Grasswitz and James, 2008). Moreover, the passive nature of dispersal by wind currents means that the crawlers do not have the capacity to actively choose to land upon a suitable host plant. These results indicate that movement of mealybugs by walking is likely to be extremely slow. First instars can be passively dispersed via wind currents. Some were shown to disperse as far as eight metres, but overall there was a rapid drop-off in dispersal with increasing distance from the source plants after three metres (Grasswitz and James, 2008). Crawlers are susceptible to extremes of temperature, desiccation, rain, predation and a lack of suitable settling sites, therefore mortality can be high for this life stage. Some mealybugs may be carried to new host plants by ants (Beardsley et al, 1982), however *P. maritimus* does not produce as much honeydew as some other species and therefore tending by ants only occurs on rare occasions (Grasswitz and James, 2008). *P. maritimus* is polyphagous, and suitable host species are widely distributed throughout New Zealand, and likely to be available to any dispersing crawler.

Given that:

- crawlers can move short distances actively or long distances passively;
- crawlers can be vulnerable to extremes of temperature and humidity, predation and other factors that result in mortality;
- crawlers that are wind dispersed are unable to actively choose to land on a suitable host plant;
- adults can move at least short distances to find suitable egg laying sites;
- *P. maritimus* is polyphagous, and suitable host species are widely distributed;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

P. maritimus reproduces sexually, so a mated female or immatures of both sexes need to be present to establish a reproductive population. For permanent establishment, male mealybugs must be able to locate females and conditions must be suitable for mating and egg laying to occur. *Pseudococcus maritimus* females release a pheromone during the day when males are active, which attracts nearby males over distances of over one metre. Males are non-feeding and live short periods of time, from one to several days. The short life span of males combined with their limited dispersal ability means that potential mates must be located nearby for males to find them and mate successfully. This likelihood is considered to be higher for mealybugs than for many other insects, due to their tendency to have an aggregated or clumped spatial distribution. Yamamura and Katsumata (1999) referred to this type of pest as gregarious, and considered them to have a higher probability of introduction into new areas via trade, due to the heightened likelihood of their locating a mate.

Despite their limited dispersal ability, the high reproductive capacity of mealybugs (Williams and Watson, 1988) means that a founding population could quickly increase in number and disperse to other nearby hosts. *P. maritimus* is established in parts of the world with climates similar to that in many parts of New Zealand.

Given that:
- individuals of opposite sexes are required for sexual reproduction;
- mealybugs have a clumped distribution which will increase the opportunities for finding a mate;
- hosts are widely distributed and climatic conditions are unlikely to be a barrier to establishment in New Zealand;

The likelihood of establishment is moderate and therefore non-negligible.

Consequence assessment

Economic consequences

The most obvious damage caused by *P. maritimus* is due to secreted honeydew, which serves as a substrate for the development of sooty mould, preventing photosynthesis. This species can also cause direct damage to fruit by entering the calyx ends of fruit (Beers et al, 1993). It is an increasingly severe pest of pears and apples in the Pacific Northwest of the USA. Indirect consequences of establishment could include an increase in pest control costs and/or disruption of existing control programmes, particularly those based on Integrated Pest Management. Establishment of this species in New Zealand could cause disruption of access to some markets. *P. maritimus* can vector viruses particularly of grapevines (Spence, 2001).
The potential economic consequences of establishment are moderate to high.

Environmental consequences

P. maritimus is polyphagous, but it is very difficult to predict what plants it will feed on when introduced to a new environment. Beever et al. (2007) suggest that, in terms of risk to native flora, and based on known attacks on native plants by exotic species present in New Zealand, sap-sucking hemipterans such as mealybugs are a relatively high risk group, particularly polyphagous species. This review was based on factors affecting the likelihood of this group of organisms becoming established, not just their anticipated impacts. *Pseudococcus longispinus*, a related species established in New Zealand, is known to attack native plant species (Spiller and Wise, 1982), but the scale of these impacts is relatively small. The displacement of native mealybug species is another possible consequence of establishment. Whilst mealybugs may be more likely than some other plant pests to have negative impacts on native flora, the scale of impacts on native species populations is likely to be low.
The potential environmental consequences of establishment are considered uncertain.

Human health consequences

There are no known human health consequences.

Risk estimation

Pseudococcus maritimus has a moderate likelihood of entry, low likelihood of exposure and moderate likelihood of establishment in New Zealand. The economic consequences are likely to be moderate to high. *As a result the risk estimate for Pseudococcus maritimus is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There is very little information available on the likelihood of crawlers successfully dispersing to a new host from a source which is not a whole plant, such as a piece of fruit.

8.19.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

The main pear growing areas in China for *Pyrus bretschneideri* and *P. pyrifolia* are the provinces of Hebei, Shandong, Shaanxi, Shanxi, Gansu, Liaoning, Jilin, Beijing, Henan, Anhui and, for *Pyrus* sp. nr. *communis*, Xinjiang Autonomous Region.
Of these *Pseudococcus maritimus* has been recorded from Xinjiang and Shandong. Pest free area status may be a viable option for some pears if its distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

Bagging of fruit

Individual bagging of fruit is likely to prevent most mealybugs from reaching the surface of the fruit. However, *P. maritimus* has been recorded from Xinjiang, where this practice is not carried out.

Phytosanitary inspection prior to export

Mealybugs are small but can be conspicuous due to their bright white colour and powdery appearance, but early instars may be inconspicuous. If honeydew is present it is often covered with a black sooty mould which should also aid detection.

Cold treatment

Live adults of this species have been intercepted twice at the New Zealand border on apricots and on pear fruit from the USA, indicating that the adults may be able to survive cold-storage. Eggs and crawlers are also highly likely to be able to survive transit, as these stages overwinter. This is unlikely to be a viable option.

Ethyl formate fumigation

Ethyl formate is a naturally occurring component in fruit with insecticidal properties, that has been used as a fumigant for stored products. A study on table grapes found that fumigation with ethyl formate in normal air gives good control of *P. maritimus*. The lethal concentration of ethyl formate for one hour at 24°C that kills 99% of tested mealybugs was 4.85% for eggs (9862 tested), 0.82% for crawlers (10 888 tested) and 1.79% for adults (787 tested). Adding 10% CO_2 significantly increased the efficacy of the treatment to an LC_{99} of 3.48 for eggs (8175 tested), 0.07% for crawlers (10 058 tested) and 1.29% for adults (723 tested) (Simpson et al, 2007). Bartlett pears tested for one hour at room temperature had a maximum tolerance dose of 3.2%. Doses in excess of this caused skin browning (Mitcham, 2005). Since eggs are unlikely to be associated with fruit, phytotoxicity appears unlikely to be a problem. This option warrants further investigation.

8.20 *Urochela luteovaria – pear stink bug*

Scientific name: *Urochela luteovaria* Distant, 1881 (Hemiptera: Urostylidae)
Common name: pear stink bug

8.20.1 Hazard identification

New Zealand status

Urochela luteovaria is not known to be present in New Zealand. Not recorded in: Larivière and Larochelle (2004), PPIN (2008).

Biology

Nymphs and adults of *Urochela luteovaria* attack leaves, twigs, flower buds and fruit of *Pyrus* during April and May. Feeding weakens the tree, retarding its growth and causing early fruit drop. *U. luteovaria* also secretes a substance which impedes even growth of the fruit and blemishes it, decreasing market value of the fruit (Tseng and Ho, 1937).

In Shandong, China, *U. luteovaria* is a pest of pears (Hoh, 1933), preferring trees that are 20–30 years old (Tseng and Ho, 1937). It has one generation per year. There are five nymphal instars and it takes one week for each early instar to develop (Hoh, 1933) and three weeks for each subsequent instar (Tseng and Ho, 1937). Second instar nymphs overwinter under the bark and resume activity in late March or early April (Tseng and Ho, 1937).

Adults appear in June and live for about 150 days (Tseng and Ho, 1937). They are not skilful flyers and move around by crawling. If disturbed they are likely to fall to the ground (Tseng and Ho, 1937). Mating occurs in September (Hoh, 1933) and oviposition takes place in late September to early October (Tseng and Ho, 1933). Females lay masses of 30–50 eggs in bark crevices (Hoh, 1933). Some hatch within four to ten days, then overwinter (Hoh, 1933; Tseng and Ho, 1937), while others do not hatch until the following March (Hoh, 1933). First instar nymphs are inactive and remain on the glue mass near their empty egg shells. Second instar nymphs do not feed before hibernating (Tseng and Ho, 1937).

Field observations indicate that a temperature between 50 and 70 °F (10–21 °C) is most favourable for feeding (Tseng and Ho, 1937).

Hosts

Malus sp., *Prunus* sp. (Schaefer et al, 2000), *Pyrus* sp. (Hoh, 1933; Schaefer et al, 2000; Tseng and Ho, 1937; Hua, 2000); *Pyrus pyrifolia* (AQSIQ, 2007); *P. bretschneideri* (AQSIQ, 2007).

Plant parts affected

Leaves, twigs, flower buds and fruit (Hoh, 1933; Tseng and Ho, 1937).

Geographical distribution

Asia: Japan (Tseng and Ho, 1937); China (Shandong, Jilin,Lianoning, Hebei, Shanxi, Ningxia, Shaanxi, Gansu, Qinghai, Henan, Hubei, Jiangsu, Jianxi, Zhejiang, Fujian, Guangxi, hunan, Guizhou, Sichaun, Yunnan) (Hoh, 1933; Hua, 2000).

Hazard identification conclusion

Urochela luteovaria has been recorded on *Pyrus* fruit. It is present in China and not known to be present in New Zealand. It is considered to be a potential hazard.

8.20.2 Risk assessment

Entry assessment

AQSIQ (2007) reports *Urochela luteovaria* as a frequent pest on *Pyrus bretschneideri* and *Pyrus pyrifolia*. Nymphs develop into adults in June, and late instar nymphs would not be associated with fruit at harvest. Eggs are laid in crevices in the bark and would also not be associated with fruit. Egg masses laid in September would hatch into first instar nymphs in October. However since first and second instar nymphs do not feed before hibernating, they are likely to remain on the bark and not be associated with fruit at harvest. Adults would be expected to feed on fruit at harvest time. Adults are likely to fall to the ground when disturbed. No dimensions for the adults have been found. However fifth instar nymphs are reported to be 9 mm long and 5 mm wide (Tseng and Ho, 1937). Assuming that adults are a similar size, any adults that remain on the fruit during picking are likely to be detected during the harvest and packing processes. *U. luteovaria* secretions blemish fruit. Such blemishes will increase the likelihood that infested fruit will be discarded.

Given that:

- adults are the only life stage likely to be associated with pear fruit at harvest;
- adults are likely to fall to the ground when disturbed;
- adults are likely to be detected during harvest and packing;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Urochela luteovaria* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for U. luteovaria is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *Urochela luteovaria* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

The prevalence of *Urochela luteovaria* in China is unknown.

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9 *Risk analysis of potential hazard organisms: Insecta: Hymenoptera*

9.1 *Hoplocampa pyricola – pear sawfly*

Scientific name: *Hoplocampa pyricola* Rohwer (Hymenoptera: Tenthredinidae)
Other relevant scientific names: *Hoplocampa minuta*
Common names: pear sawfly, Japanese pear sawfly

9.1.1 Hazard identification

New Zealand status

Hoplocampa pyricola is not known to be present in New Zealand. Not recorded in: PPIN (2009), Berry (2007).

Taxonomy

Harukawa (1924) used the name *Hoplocampa minuta* for the Japanese pear sawfly. It was later determined that the Japanese pear sawfly differs from the European plum sawfly, *Hoplocampa minuta* and the Japanese species is *Hoplocampa pyricola* (Rohwer, 1924). The species discussed by Harukawa (1924) is *H. pryicola*.

Biology

The pear sawfly has been reported to cause considerable damage to pear crops in Japan (Harukawa, 1924). Information on its biology is derived from observations in Japan.

H. pyricola has one generation per year. The adult appears about mid-April in Japan and lives 10–19 days. Females lay approximately 35 eggs, which are inserted into a small cavity in the tissues of the outside upper part of the calyx of buds. The cut is covered with a viscous fluid that dries and turns black, becoming brownish in a few days (Harukawa, 1924).

The larval period is 2–3 weeks; the larva having five instars. When newly-hatched, the larva feeds on the tissues that enclosed the egg, and then tunnels through those of the calyx or gnaws small shallow depressions near the base of the anthers. In a few days, it enters the fruit or in some cases leaves the fruit in which it hatched and bores into another, near its calyx end. As the calyx is injured at its base, it withers and drops shortly after the petals have fallen. Larvae may move to several different fruit before leaving the developing fruit, either while the fruit is still on the tree or when it has fallen to the ground. Pupation takes place in the soil. Most larvae have left the fruit by the end of May (Harukawa, 1924).

Hosts

Pyrus sp. (Rohwer, 1924; Yago, 1933); *Pyrus pyrifolia* (AQSIQ, 2007; Harukawa, 1924); *Pyrus bretschneideri* (AQSIQ, 2007).

Plant parts affected

Young fruit of *Pyrus* (Harukawa, 1924); pear fruit (Rohwer, 1924).

Geographical distribution

Asia: China (AQSIQ, 2007); Japan (Rohwer, 1924; Yago, 1933).

Hazard identification conclusion

Hoplocampa pyricola is associated with *Pyrus* spp. and is present in China. It is associated with fruit and is not known to be present in New Zealand. It is considered to be a potential hazard.

9.1.2 Risk assessment

Entry assessment

Only the larvae of *H. pyricola* are associated with the fruit of pears. Since they infest the flowers and young fruitlets, which drop prematurely, the larvae are highly unlikely to be associated with *Pyrus* fruit at harvest. Most larvae have left the fruit by the end of May.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Hoplocampa pyricola* entering New Zealand with *Pyrus* fresh fruit from China is negligible. *As a result the risk estimate is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *Hoplocampa pyricola* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

There is little available information on the distribution and biology of this species in China. It is assumed that it will be similar to that in Japan.

9.2 *Vespa mandarinia – giant hornet*

Scientific name: *Vespa mandarinia* Smith (Hymenoptera: Vespidae)
Common name: giant hornet

9.2.1 Hazard identification

New Zealand status

Vespa mandarinia is not known to be present in New Zealand. Not recorded in: Berry (2007), PPIN (2009).

Biology

Vespa mandarinia is a serious predator of honeybees in Japan (Matsuura and Sakagami, 1973). It nests underground. Food sources vary throughout the year. The sap of oak trees is the main source for post-hibernating females prior to establishing a nest (Yoshimoto et al, 2007). Once the nest is developed co-operative attacks on honey bees are common (Matsuura and Sakagami, 1973). Adults are large (Matsuura and Sakagami, 1973) with a body length of approximately 5 cm.

Hosts

Pyrus pyrifolia (AQSIQ, 2007); *Pyrus bretschneideri* (AQSIQ, 2007).

Plant parts affected

Adults of *Vespa* spp. pierce ripe fruit (Hill, 1987). Post-hibernating females particularly feed on sap of oak trees (*Quercus* spp.) (Yoshimoto et al, 2007).

Geographical distribution

Asia: China (AQSIQ, 2007; Wang et al, 1985; Nguyen and Carpenter, 2002); northern India; Sri Lanka; Taiwan; Russia; Korea; Japan; continental Southeast Asia including Vietnam (Nguyen and Carpenter, 2002)

Hazard identification conclusion

Vespa mandarinia is reported to be associated with *Pyrus* spp. and is present in China. It is not known to be present in New Zealand. Adult wasps typically feed on ripe fruit. *Vespa mandarinia* is considered a potential hazard.

9.2.2 Risk assessment

Entry assessment

Vespa mandarinia is primarily a predatory wasp. Since it nests underground adults are the only life stage that could be associated with mature fruit. Whilst wasps in the genus *Vespa* commonly feed on ripe fruit, no reports have been found of *V. mandarinia* feeding in this way. The large size of adults means that any that are associated with fruit at harvest would be expected to be detected during the harvest and packing process. Adults are also mobile and would be expected to fly off the fruit when disturbed.

The likelihood of entry considered to be negligible.

Risk estimation

Vespa mandarinia has a negligible likelihood of entry.
As a result the risk estimate for V. mandarinia is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.

Note that although *Vespa mandarina* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

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10 *Risk analysis of potential hazard organisms: Insecta: Lepidoptera*

10.1 *Acleris fimbriana – fruit tree tortrix*

Scientific name:	*Acleris fimbriana* (Thunberg, 1791) (Lepidoptera: Tortricidae)
Other relevant scientific names:	*Tortrix fimbriana* Frölich, 1828
Common names:	fruit-tree tortrix, cranberry tortricid

10.1.1 Hazard identification

New Zealand status

Acleris fimbriana is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), Charles (1998), PPIN (2008).

Biology

In northern China, there are four generations of *Acleris fimbriana* per year (Liu and Meng, 2003). Larvae feed within rolled leaves at apices of the branches of the host plant (Meijerman and Ulenberg, 2000) and can consume all of the foliage of apple trees, leaving only the leaf midvein (Liu and Meng, 2003). The autumn generation adults hibernate over winter (Meijerman and Ulenberg, 2000).

Hosts

Malus domestica, *Prunus persica* (CPC, 2007; Liu and Meng, 2003); *Crataegus* spp. (Liu and Meng, 2003); *Prunus* spp. (Liu and Meng, 2003; Meijerman and Ulenberg, 2000); *Pyrus bretschneideri* (AQSIQ, 2007); *Pyrus pyrifolia* (AQSIQ, 2007); *Vaccinium* spp. (Meijerman and Ulenberg, 2000).

Plant parts affected

Larvae of *A. fimbriana* feed on rolled leaves at the apices of branches in the host plant (Liu and Meng, 2003; Meijerman and Ulenberg, 2000). Eggs of other species of *Acleris* are laid on the bark of the host plant or on the underside of leaves (Meijerman and Ulenberg, 2000). Choi and others (2004) attribute fruit damage (0.67% over ten years) to a mixed population of pests that were collected from a Korean apple orchard. The contribution of *A. fimbriana* to this fruit damage is not specified (Choi et al, 2004).

AQSIQ (2007) lists *A. fimbriana* as an infrequent pest of *Pyrus bretschneideri* and *P. pyrifolia* in China. No reports of it infesting the fruit of pears have been found.

Geographical distribution

Asia: China (Beijing, Liaoning, Hebei, Henan, Shanxi, Shaanxi, Shandong, Gansu) (Liu and Meng, 2003; CPC, 2007; Meijerman and Ulenberg, 2000; Zhang, 1994); Republic of Korea (Meijerman and Ulenberg, 2000).
Europe: Russia (Byun and Yan, 2004).

The distribution of *Acleris fimbriana* within China appears to be limited to the north, where the climate is mid- to warm-temperate.

Hazard identification conclusion

Acleris fimbriana is present in China. It is not known to be present in New Zealand. AQSIQ (2007) states that it is an infrequent pest of *Pyrus bretschneideri* and *P. pyrifolia*, but no evidence that it is associated with *Pyrus* fruit has been found. *Acleris fimbriana* is not considered to be a potential hazard on fresh *Pyrus* fruit from China.

Note that although *Acleris fimbriana* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

10.2 *Acrobasis pirivorella – pear fruit moth*

Scientific name: *Acrobasis pirivorella* (Matsumura, 1900) (Lepidoptera: Pyralidae)

Other relevant scientific names: *Ectomyelois pirivorella* Matsumura; *Ectomyelois pyrivorella* Matsumura; *Eurhodope pirivorella* Matsumura; *Nephopteryx pyrivorella* Matsumura; *Numonia pirivorella* Matsumura; *Numonia pyrivorella* Matsumura; *Rhodophaea pirivorella* Matsumura

Common names: pear fruit moth, pear pyralid, pear driller

10.2.1 Hazard identification

New Zealand status

Acrobasis pirivorella is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), Charles (1998), PPIN (2008).

Biology

The larvae of *Acrobasis pirivorella* infest buds, flowers and fruit; a single larva can destroy up to three buds, flowers and fruit in its lifetime (Shutova, 1977). Larvae overwinter at the first or second instar in a thin white cocoon within the buds (EPPO 1997). Infested buds do not fall, but remain on the tree without developing. In spring the larvae emerge and move to fresh buds. They eat out the core of developing fruit and move on to another fruit (Shutova, 1977). In Russia, older larvae move to the surface of developing fruit in May and spin a silken web around the fruit to keep it attached to the tree (CPC, 2007) prior to penetrating the fruit to pupate. They enter the fruit near the calyx end, or on the side of the fruit, making a prominent hole with an overhanging lip of silk and excreta. They eat out the heart of the fruit then pupate, sealing the opening with a web (CPC, 2007). Adults emerge between July and August in Russia. Females lay approximately 120 eggs on flower buds. Larvae hatch in 8–10 days and penetrate the buds to form overwintering cocoons (CPC, 2007).

There is one generation per year in Russia and 2–3 in Japan (Shutova, 1977). In warmer countries such as China, the first generation adults reportedly lay eggs on fruits, within which a second generation develops to produce adults in September. These adults then lay eggs on flower buds and the resulting larvae overwinter.

Fruits that have been infested by larvae remain black and shrivelled on the tree. This is characteristic of *A. pirivorella* attack (Shutova, 1977).

Optimal climatic conditions for survival and development are moderate rainfall and high humidity. In Russia, *A. pirivorella* reportedly occurs wherever pears are grown. The natural spread by adult flight is over relatively short distances and the main means of spread is likely to be trade of planting material and infested fruits (Shutova, 1977).

The percentage infestation of fruit is 60–70% (Shutova, 1977).

Hosts

A. pirivorella feeds on *Pyrus* spp. only. There is no indication that it attacks other fruit trees (Shutova, 1977). *Pyrus* spp. (Zhang, 1994); *Pyrus* sp. nr. *communis*, *Pyrus pyrifolia*; *Pyrus bretschneideri* (AQSIQ, 2007).

Plant parts affected

Eggs of *A. pirivorella* are laid on flowers and fruit. Larvae feed on buds and fruit and pupate in fruit. (CPC, 2007; Shutova, 1977).

Geographical distribution

Asia: China (Heilongjiang, Jilin, Liaoning, Nei Menggu [Neimongol], Shaanxi) (Zhang, 1994; CPC, 2007); Taiwan (CPC, 2007); Japan, Korea (Zhang, 1994).
Europe: Russia (CPC, 2007).

Hazard identification conclusion

Acrobasis pirivorella has been recorded on *Pyrus*, and is associated with the fruit. It is present in China. It is not known to be present in New Zealand, and is considered to be a potential hazard.

10.2.2 Risk assessment

Entry assessment

All life stages (egg, larva, pupa and adult) of *Acrobasis pirivorella* are associated with fruit of Pyrus.

Adult *A. pirivorella* are mobile and are not likely to be associated with the fruit of *Pyrus* during harvest. They are also highly visible, with a wingspan of 14.5–21.5 mm, and greyish in colour with a violet tinge (CPC, 2007).

Eggs are 1 mm long, flat and elliptical in shape. They are yellow when newly laid, but darken to a reddish tint before hatching (EPPO, 1997). Eggs are laid on the outer surface of the fruit. Assuming that there are at least two generations in China, first generation eggs are laid on fruit. These develop into adults in September and these adults lay eggs on flower buds (Shutova, 1977). Therefore the lifestages most likely to be associated with fruit at harvest are larvae and pupae. Both the larvae and pupae may be detected by the presence of accumulated excreta and webbings near the entry holes of the fruit.

AQSIQ (2007) states that *A. pirivorella* occurs frequently on all three pear species (as synonym *Nephopteryx pririvorella*) in China.

Given that:
- larvae and pupae are likely to be present in fruit at harvest time;
- some infested fruit are likely to be detected and discarded during the harvest and packing process;
- *A. pirivorella* appears to be prevalent in pear orchards;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Fresh imported *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. Infested fruit are more likely to be thrown away. The waste material generated could allow some *A. pirivorella* larvae or pupae to develop into adults, disperse and find a suitable host.

Adults developing from pupae fly relatively short distances. Pears are the only known host. These are fairly commonly planted in New Zealand in domestic gardens. However their distribution is patchy.

Given that:

- adults are mobile, at least to some degree;
- *A. pirivorella* is restricted by *Pyrus* hosts, which are patchily distributed in New Zealand;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

A. pirivorella reproduces sexually and individuals of both sexes need to be present to establish a reproductive population. The production of sex pheromones may increase the likelihood of successfully detecting a mate. There are unlikely to be multiple larvae or pupae per fruit. There is little available information on the eco-climatic tolerances of *A. pirivorella*. In Russia, it is considered to be capable of survival wherever pears are grown.

Given that:

- *A. pirivorella* reproduces sexually;
- the host range is very narrow;
- climate is unlikely to be a barrier to establishment;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

There is no indication that *A. pirivorella* occurs on anything other than pear trees. In the Far Eastern territories of Russia it is considered to be the most serious pest of cultivated pears and it is also of economic importance in Japan (EPPO, 1997). Whilst the impact for individual pear growers would be expected to be high, the potential economic impact to New Zealand is considered to be low.

Since *A. pirivorella* is confined to Asia, if the pest was to establish in New Zealand, there may be an impact on market access, for New Zealand pears.

Pears are planted in domestic gardens and would likely to be adversely effected if *A. pirivorella* established in New Zealand.
The potential economic consequences are considered to be low.

Environmental consequences

There is no indication that A. pirivorella occurs on any plant other than pear trees.

The potential environmental consequences are considered to be negligible.

Human health consequences

There are no known human health consequences.

Risk estimation

Acrobasis pirivorella has a low likelihood of entry, exposure, and establishment in New Zealand. The potential economic impact within New Zealand is low. *As a result the risk estimate for A. pirivorella is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There is relatively little accessible information on the biology of *A. pirivorella.*

10.2.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest-free area

A. pirivorella appears likely to be widespread in China, and pest-free area status is not likely to be a viable risk management option. The main growing area for *Pyrus* sp. nr. *communis* is Xinjiang Autonomous Region. *A. pirivorella* has not apparently been reported from Xinjiang and pest free area status may be a viable option for pears from this area if its distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

In-field control and surveillance

A. pirivorella produces sex pheromones. This may facilitate targeted surveys of export orchard areas to detect its presence. Detection in the surveillance programme would indicate the failure of in-field control and any fruit from an infested area should not be permitted entry to New Zealand.

Bagging of fruit

Adults of *A. pirivorella* are relatively large, with a wingspan of 14–22 mm (EPPO, 1997). The practice of bagging individual fruit is likely to prevent adult females from laying eggs on the fruit surface or the calyx. However there is a period of up to four weeks from fruit set before fruit are bagged, during which eggs could be laid. *Pyrus* sp. nr. *communis* are not bagged.

Phytosanitary inspection prior to export

The lifestages most likely to be associated with fruit at harvest are larvae and pupae. Both the larvae and pupae may be detected by the presence of accumulated excreta and webbings near the entry holes of the fruit. Furthermore, infested fruits are normally retarded in growth and have a shrivelled appearance. It is likely that visual inspection would detect most infested fruit.

Cold treatment

The thermal tolerances of *A. pirivorella* are not known. First or second instar larvae are the over-wintering life stage. It is not known whether late instar larvae or pupae would survive cold treatment.

Fumigation

EPPO suggest that the quarantine requirements for *Carposina sasakii* (syn. *C. niponensis*) in relation to fruits of *Pyrus* are sufficient to cover *A. pirivorella* (EPPO, 1997). These refer to a fumigation schedule published in Russia of $23g/m^3$ at >1°C for over-wintering larvae and 17–20 g/m^3 for summer generation larvae (EPPO). However methyl bromide fumigation is considered damaging to the types of fruit for which access is being sought (see Chapter 4).

A combination of fruit bagging and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

10.3 *Adoxophyes orana – summer fruit tortrix moth*

Scientific name: *Adoxophyes orana* (Fischer von Roeslerstamm, 1834) (Lepidoptera: Tortricidae)

Other relevant scientific names: *Acleris reticulana* Haworth; *Adoxophyes congruana* Walker; *Adoxophyes fasciata* Walsh; *Adoxophyes reticulana* Hübner; *Adoxophyes tripsiana* (Eversmann); *Cacoecia reticulana* (Hübner); *Capua congruana* (Walker); *Capua reticulana* Hübner; *Tortrix orana* (Fischer); *Tortrix reticulana* (Hübner)

Common names: summer fruit tortrix, apple peel tortricid, smaller tea tortrix

10.3.1 Hazard identification

New Zealand status

Adoxophyes orana is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Adoxophyes orana is a major pest of fruit crops, particularly apple and pear, in temperate regions (Davis et al, 2005). It is the most important of a complex of leafrolling species in Europe (Dickler, 1991).

Larvae of *A. orana* have five to six instars (de Jong et al, 1971). First generation larvae feed on leaves, buds, flowers and developing fruit (Davis et al, 2005). Second generation larvae hatch in autumn and feed in the fruit flesh, leaving either sting marks or large, irregular depressions on the fruit surface (Dickler, 1991). They overwinter as diapausing second to fourth instars, spinning silken shelters, along the lower surface of the leaves (Janssen, 1958) or under loose bark or other sites (Dickler, 1991). Larvae resume feeding on young leaves, buds and flowers in spring (Davis et al, 2005; Janssen, 1958). Warmer conditions can produce a partial third generation, but several other factors such as humidity, host availability and photoperiod also influence development (de Jong et al, 1971).

Adult *A. orana* live from five days to two weeks, depending on temperature (Davis et al, 2005). Flights last for four weeks and, although dispersal is somewhat limited, males can fly up to 400 m (CPC, 2007; Davis et al, 2005). Mating and flight activity is very restricted when temperatures fall below 13ºC (Davis et al, 2005).

Oviposition is initiated at temperatures above 10ºC, at an accumulated 135 degree days (Charmillot and Megevand, 1983). Eggs are laid in masses of 25–150 eggs on leaves, fruit and sometimes on the tree trunk (CPC, 2007). Eggs hatch in eight to twenty days (Davis et al, 2005; Fluckiger and Benz, 1982).

The larvae of the first generation bore large, deep holes in the fruit of apple and pear, causing extensive damage (Janssen, 1958). Deep tunnels can be found in apples, at the base of pedicels as well as grooves 3–6mm wide (Janssen, 1958). In addition, first generation larvae spread and damage whole leaves and young shoots (CPC, 2007). The behaviour of the second generation larvae is similar to that of the first, but feeding is superficial, more on the surface of the fruit, and small holes of less than 5 mm in diameter occur (Balachowsky, 1966; Janssen, 1958). Up to 50% of fruit can be infested and well-managed orchards with many young shoots are particularly susceptible (de Jong, 1971). If larvae are disturbed, they can fall on a spun thread (CPC, 2007). Larvae pupate near where they have been feeding. The pupae are often hidden under leaves that are stuck together to a branch or to a fruit (CPC, 2007).

Hosts

A. orana is polyphagous, with most hosts being fruit and forest trees in members of the following families: Aceraceae, Anacardiaceae, Betulaceae, Cannabaceae, Caprifoliaceae, Ericaceae, Fabaceae, Fagaceae, Liliaceae, Malvaceae, Oleaceae, Rosaceae, Salicaceae, Saxifragaceae, Tiliaceae and Ulmaceae.

Acer campestre (CPC, 2007); *Alnus* sp. (Janssen, 1958); *Betula* (CPC, 2007); *Carpinus betulus* (de Jong et al, 1971); *Crataegus* spp., *Cydonia oblonga* (de Jong et al, 1971; Janssen, 1958); *Fagus sylvatica* (Janssen, 1958); *Fraxinus* spp., *Forsythia suspensa* (CPC, 2007); *Gossypium herbaceum* (Janssen, 1958); *Humulus* sp., *Laburnum anagyroides*, *Ligustrum* sp., *Lonicera xylosteum*, *Malus baccata* (CPC, 2007); *Malus domestica* (Fluckiger and Benz, 1982); *Medicago* spp. (Janssen, 1958); *Menyanthes trifoliata*, *Pistacia lentiscus*, *Populus* sp. (CPC, 2007); *Prunus armeniaca*, *Prunus avium*, *Prunus domestica* (Janssen, 1958); *Prunus padus* (de Jong et al, 1971); *Prunus persica* (Janssen, 1958); *Prunus salicina* (CPC, 2007); *Prunus triloba* (Janssen, 1958); *Pyrus* sp. (Feng, 1998); *Pyrus communis* (Balachowsky, 1966; Fluckiger and Benz, 1982, Janssen, 1958); *Pyrus pyrifolia* (AQSIQ, 2007); *Pyrus bretschneideri* (AQSIQ, 2007); *Quercus* spp. (Janssen, 1958; Fluckiger and Benz, 1982); *Rhododendron catawbiense* (CPC, 2007); *Ribes nigrum* (Janssen, 1958); *Ribes rubrum*, *Ribes uva-crispa*, *Rosa* sp. (de Jong et al, 1971; Janssen, 1958); *Rubus idaeus*, *Rosa canina* (de Jong et al, 1971; Janssen, 1958); *Rubus fruticosus*, *Salix caprea*, *Salix viminalis* (de Jong et al, 1971); *Symphoricarpos albus*, *Syringa vulgaris* (Janssen, 1958); *Tilia* spp., *Ulmus minor* (de Jong et al, 1971); *Vaccinium*, *Vicia faba* (Davis et al, 2005).

Plant parts affected

Larvae feed on buds, leaves, fruit and shoots (Davis et al, 2005; Janssen, 1958). Eggs are laid on leaves, fruit and bark (CPC, 2007).

Geographical distribution

A. orana occurs throughout much of Europe and Asia. In China it is reported from Beijing, Hebei, Liaoning, Shandong, Sichuan (CPC, 2007; Davis et al, 2005; Feng, 1988; Zhang, 1994).

Hazard identification conclusion

Adoxophyes orana has been recorded on *Pyrus*, and is associated with the fruit and flowers of host plants. It is present in China. It is not known to be present in New Zealand, and is considered to be a potential hazard.

10.3.2 Risk assessment

Entry assessment

Adoxophyes orana is present in some of the main pear-growing regions of China. Pupae are only associated with fruit when the leaves, under which they are hiding are stuck to fruit. It is assumed that these would be detected and discarded during the harvest and packing processes. Adults are not likely to be associated with fruit.

The larval and egg stages of *A. orana* are associated with the leaves and fruit of host plants, including *Pyrus*. Eggs are yellowish in colour and are laid on leaves and fruit. Eggs are laid in masses on the surface of the fruit and are likely to be readily detected. They are not likely to be present on the fruit at harvest.

Larvae are external and internal feeders; therefore it is possible that larvae would be transported either on or inside fruit (Janssen, 1958). Multiple holes made by larvae are likely to be visible and obviously damaged fruit is unlikely to be picked or packed. Larvae on the outside of fruit can fall on a spun thread when disturbed and this may mean they are less likely to be associated with picked fruit.

Transit time from China to New Zealand by sea is approximately four weeks. Larvae of *A. orana* can take up to 37 days for development, which exceeds the transit time. However, developmental time of larvae increases substantially at cooler temperatures and survival of larvae is reduced at extreme temperatures (Milonas and Savopoulou-Soultani, 2000). *A. orana* overwinters as diapausing second to fourth instars. It is not known whether cold temperatures during transit would initiate diapause.

Adoxophyes spp., including *A. orana*, have been intercepted in fresh fruit imports of oranges and apples at the New Zealand border. Tortricids are extremely difficult to identify, especially in the egg and larval stages; over 10 000 unidentified tortricids were intercepted in USA between 1985 and 2004 (Davis et al, 2005).

Given that:

- larvae are likely to be present in fruit at harvest time;
- some infested fruit are likely to be detected and discarded during the harvest and packing process;
- larval development periods exceed the time required for shipment to New Zealand;

The likelihood of entry is considered to be moderate and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed in large amounts throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. Infested fruit are more likely to be thrown away. The waste material generated could allow some *A. orana* larvae to disperse and find a suitable host. Larvae are capable of limited dispersal via wind-aided ballooning on silken threads, but there are no quantitative records of distances achieved. They pupate close to their feeding sites. Adult males are capable of flying up to 400 m making them more likely to successfully disperse. Adult females are said to have limited dispersal ability.

Many plants grown in New Zealand for horticultural purposes are host plants within the known range of *A. orana*. These include berry fruits such as gooseberries, blueberries, blackcurrants, raspberries and stone fruit such as peaches, pears, apricots, and plums. Poplars, willows and roses are also host plants, and there would be no shortage of host material available for the moth year round.

Given that:

- larvae and adults are mobile, at least to some degree;
- host plants are widely distributed in New Zealand in both domestic and commercial situations;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

Temperature is the most important variable influencing development in *A. orana*. If warm weather persists, the number of generations is increased. A threshold temperature of 10ºC is required for development of eggs and diapausing larvae. The threshold temperature for the development of the first generation larvae is 7–8ºC (Charmillot and Megevand, 1983).

A. orana has established successfully in several countries in continental Europe that have cool-temperate climates. This indicates that climate is unlikely to be a barrier to it establishing in New Zealand. Since *A. orana* overwinters during the larval stage, it would be able to hibernate before conditions became unfavourable (in autumn or winter, depending in which region of New Zealand it is situated), and resume feeding once conditions become favourable (spring or summer). Flights of moths occur at temperatures over 13ºC, and would be seasonal, limited to summer for most regions of New Zealand, and also autumn for warmer regions.

A. orana reproduces sexually. Multiple larvae may occur in a fruit, since eggs are laid in masses. Simultaneous breaking of diapause and production of sex pheromones would result in adults emerging at the same time, thereby increasing the likelihood of mating and a viable population establishing.

Given that:

- *A. orana* reproduces sexually, but multiple larvae in a fruit will increase the likelihood of mating;
- hosts are widely distributed;
- climate is unlikely to be a barrier to establishment;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

Adoxophyes orana occurs in mixed populations with other closely-related species, making it difficult to assess its economic impact (Davis et al, 2005). Larvae of *A. orana* could cause damage to fruit of many economically important crops in New Zealand, for example, apples and pears. Feeding by summer generation larvae often leads to rotten fruit as the damage is internal and more extensive, but damage from winter generation larvae is more to the outer layers (fruit skin and small, shallow holes into fruit, causing fruit quality to drop or desiccation) (Dickler, 1991).

Crop losses have reached 50% in well-managed orchards in Europe as a result of *A. orana* attack (CPC, 2007; Davis et al, 2005). *A. orana* prefers Rosaceae hosts, mainly pears and apples (Davis et al, 2005). New Zealand has a large pipfruit industry, consisting of apples and pears, and infestation by *A. orana* could lead to serious losses in the industry. Furthermore, since *A. orana* is confined to Europe and Asia, if the pest was to establish in New Zealand, there may be an impact on market access, particularly the export of New Zealand pomes and stonefruit and other Rosaceae to USA or Australia.

Fruit trees in the Rosaceae are widely planted in domestic gardens and would be adversely affected if *A. orana* established in New Zealand.

Salicaceae trees are widely used throughout New Zealand as windbreaks, urban amenities or for erosion control. Defoliation of these trees could also have an adverse economic impact.
The potential economic consequences are considered to be high.

Environmental consequences

Host plants of *Adoxophyes orana* are widely distributed throughout New Zealand. The native flora of New Zealand that *A. orana* could potentially have an impact on includes:

1. Ericaceae (New Zealand genera include *Androstoma, Archeria, Cyathodes, Dracophyllum, Epacris, Gaultheria, Leptecophylla, Leucopogon, Pentachondra* and *Sprengelia*)
2. Fabaceae (New Zealand genera include *Canavalia, Carmichaelia, Clianthus, Corallospartium, Montigena and Sophora*)
3. Malvaceae (New Zealand genera include *Entelea, Hibiscus, Hoheria and Plagianthus*)
4. Oleaceae (*Nestegis*)
5. Rosaceae (New Zealand genera include *Acaena, Geum, Potentilla and Rubus*).

Native broadleaved forests in the North Island may be vulnerable to attack from the pest, especially in the north of the North Island, where temperatures do not fall below 10°C regularly in winter. *A. orana* is less likely to attack native plants than horticultural species. Because *A. orana* is a pest of *Fagus* spp. overseas, *Nothofagus* species in New Zealand may be more vulnerable than other native plants.
The potential environmental consequences are uncertain.

Human health consequences

There are no known human health consequences.

Risk estimation

Adoxophyes orana has a low likelihood of entry and a moderate likelihood of exposure, and establishment in New Zealand. The potential economic impact within New Zealand is high. *As a result the risk estimate for A. orana is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

It is uncertain how far larvae will disperse to pupate. We assume that there will be host plants sufficiently close to discarded fruit for exposure to occur.

10.3.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area status

A. orana is widespread in China, and pest-free area status is not likely to be a viable option. The main growing area for *Pyrus* sp. nr. *communis* is Xinjiang Autonomous Region. *A. orana* has not been reported from Xinjiang and pest free area status may be a viable option for pears from this area if its absence can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

In-field control and surveillance

A. orana produces sex pheromones. This may facilitate targeted surveys of export orchard areas to detect its presence. Detection in the surveillance programme would indicate the failure of in-field control and any fruit from an infested area should not be permitted entry to New Zealand.

Bagging of fruit

Adults have a wingspan of 17–19 mm in the male, and 19–22 mm in the female (HYPP Zoology, 2008). Bagging of fruit is likely to prevent adult *A. orana* from laying eggs on the surface of fruit. Bagging may not occur until four weeks after fruit set, and eggs could be laid during this period. However, such eggs would be first generation, and it is larvae from the second generation that are most likely to be transported in pear fruit. *Pyrus* sp. nr. *communis* fruit are not bagged, so this will not be an effective measure for these fruit.

Phytosanitary inspection prior to export

Larvae are external and internal feeders; the holes made in fruit by larvae can be quite large and are likely to be easily seen.

Cold treatment

Since larvae overwinter, cold treatment is unlikely to be an effective option.

A combination of fruit bagging and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

10.4 *Archips spp. – leafrollers*

Scientific name: *Archips breviplicanus* (Walsingham, 1900) (Lepidoptera: Tortricidae)
Other relevant scientific names: *Archippus breviplicanus* Walsingham; *Archips breviplicana* Walsingham; *Tortrix breviplicana* Walsingham.
Common names: Asiatic leafroller

Scientific name: *Archips crataeganus* (Hübner, 1799)
Other relevant scientific names: *Cacoecia crataegana* Hübner; *Olethreutes crataeganus* Hübner; *Tortrix crataegana* Hübner
Common names: hawthorn leafroller, hawthorn tortricid, brown oak tortrix

Scientific name: *Archips fuscocupreanus* (Walsingham, 1900)
Other relevant scientific names: *Archips ishidai* (Matsumura, 1900); *Archips punicae* (Matsumura, 1931); *Cacoecia fuscocupreana* Walsingham; *Ptycholoma fuscocupreanum* Walsingham
Common names: apple tortrix, apple leafroller, Asiatic leafroller, cherry tree tortricid

Scientific name: *Archips rosana* (Linnaeus, 1758)
Other relevant scientific names: *Archips rosanus* (Linnaeus); *Cacoecia hewittana* (Busck); *Cacoecia rosana* (Linnaeus); *Tortrix hewittana* Busck; *Tortrix laevigana* Schiffermueller; *Tortrix rosana* (Linnaeus)
Common names: European leaf roller, rose twist moth, rose leaf folder

Scientific name: *Archips xylosteanus* (Linnaeus, 1758)
Other relevant scientific names: *Archips xylosteana* (Linnaeus, 1758); *Cacoecia xylosteana* Linnaeus; *Tortrix xylosteana* Linnaeus
Common names: variegated golden tortrix, apple leafroller, forked red barred twist moth

10.4.1 Hazard identification

New Zealand status

Archips breviplicanus, A. crataeganus, A. fuscocupreanus, A. rosana, and *A. xylosteanus* are not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

These species are part of a group of tortricids that attack buds, and may cause considerable damage in some areas. They have a common life cycle in Europe: there is usually one generation per year; hibernation occurs in the egg stage; the newly hatched larvae start to feed at the green-tip stage; larvae may be associated with young fruit, but not with mature fruit (Dickler, 1991). Clausen (1927) stated that the larvae of *Archips podanus* bore into young citrus fruit, otherwise *Archips* spp. are only known to attack the surface of fruit. Given this common biology, these species are assessed as a group.

Larvae of *A. crataeganus* hatch at the flowering stage of the host plant (Anon., 1965) and they have five larval instars (Meijerman and Ulenberg, 2000). Larvae crawl immediately to the crown of the tree and start to feed on the underside of the leaves, as they spin fine webs (Meijerman and Ulenberg, 2000). Larval damage to leaves is considered insignificant unless there is a high population (Meijerman and Ulenberg, 2000). In Russia, *A. crataeganus* was reported to affect about 20% of young apple fruit in an orchard and up to 70% of the leaves in another (Anon., 1965).

Eggs of *A. fuscocupreanus* overwinter and remain in diapause until the following spring (CPC, 2007). In colder climates, where ground temperatures fall below zero in winter, the eggs terminate diapause and instead go into gradual development. There are five to six larval instars, taking forty to fifty days to complete development (Meijerman and Ulenberg, 2000). The larvae feed initially on flower buds, but leaves, flowers and young fruit are all damaged by mature larvae, which cause early fruit drop and/or malformation with characteristic deep hollows (Meijerman and Ulenberg, 2000). Pupation occurs between rolled or spun leaves and this stage takes ten days to a fortnight (Meijerman and Ulenberg, 2000).

Larvae of *Archips rosana* can cause severe damage to their host plants; they mainly feed on leaf rolls but will also feed on the buds, flowers and fruit (CPC, 2007). Larval damage to young fruit results in a local cessation of growth and deformity; the early season feeding damage to the surface of developing apple and pear fruitlets leads to scarred and misshapen mature fruit, and causes the commercial grade to drop (CPC, 2007; INRA, 2008). Damage can cause the bud peduncle to drop (CPC, 2007; INRA, 2008). Pupation takes place in rolled leaves during June and July, lasting for 25–40 days. Adults emerge in early September (Bradley et al, 1973; CPC, 2007), but the time of pupation and adult emergence is dependent on temperature (CPC, 2007). Greenish egg masses are laid on bark in August (Bradley et al, 1973). Overwintering occurs in the egg stage. Egg masses are protected against low temperatures by the sheltered positions in which they are laid and by a green secretion (Guennelon and Tort, 1958). *A. rosana* is widely distributed but has attained pest status in only limited fruit growing areas (Dickler, 1991).

Larvae of *Archips xylosteanus* have been reported feeding on the leaves, flower buds and the surface of young fruit of apple and pear in Korea, the Saragossa Province of Spain, Sweden and Japan (Alfaro, 1950; Sylven, 1958; Nawa, 1939; Nakayama, 1936; Yago, 1931). They feed for a month before pupating amongst leaves and flowers (Nakayama, 1936). Pupation lasts for about 11 days, after which adults emerge and survive for up to ten days. Oviposition takes place on the bark and each female lays between 32 and 206 eggs (Nakayama, 1936).

Archips breviplicanus primarily attacks leaves. It differs from other species in this group in having multiple generations. In the southern part of its range there are three, sometimes overlapping, generations; in the northern part there are two (Meijerman and Ulenberg, 2000). Eggs are laid in large masses on the underside of fully-expanded leaves. Hatching occurs after the end of August. The larvae undergo diapause at the third or fourth instar when day-length decreases, and spin hibernacula under flakes of bark or under leaf pieces webbed on branches (Meijerman and Ulenberg, 2000). They become active after the emergence of buds in spring, on which they feed. Five weeks later, they move to new leaves to pupate and pupation lasts 8–12 days. Non-diapause generation larvae pass 5–8 instars and require up to 35 days for full development (Meijerman and Ulenberg, 2000). In Japan, *A. breviplicanus* larvae feed on the young leaves of pears in early spring and subsequent generations attack the leaves and the surface of fruit (Hitomi, 1935; Meijerman and Ulenberg, 2000). Hitomi (1935) stated that 30–40% of the fruit can be injured. Meijerman and Ulenberg (2000) state that *A. breviplicanus* causes 'shallow feeding scars' on apple fruit that are in contact with leaves.

Hosts

Archips breviplicanus

Rosaceae; fruit and forest trees including:
Alnus japonica, *Crataegus* sp., *Cydonia oblonga*, *Elaeagnus* sp., *Fragaria ananassa*, *Fraxinus lanuginosa*, *Fraxinus rhynchophylla*, *Juglans mandshurica sieboldiana*, *Malus pumila*, *Malus baccata*, *Morus bombycis*, *Populus nigra*, *Prunus persica*, *Prunus ×yedoensis*, *Prunus salicina*, *Prunus armeniaca*, *Pyrus* sp., *Pyrus simonii* (= *Pyrus ussuriensis*), *Quercus mongolica*, *Ribes grossularia*, *Rosa* sp., *Rubus* sp., *Salix* sp., *Triticum aestivum*, *Ulmus propinqua* (Meijerman and Ulenberg, 2000); *Malus domestica* (CPC, 2007); *Pyrus communis* (Okazaki and Izawa, 2003; CPC, 2007).

Archips crataeganus

Major hosts: *Acer* sp., *Betula* sp., *Crataegus* sp. (Meijerman and Ulenberg, 2000); *Gingko* sp. (Sun et al, 1998); *Fraxinus* sp., *Mespilus* sp., *Populus* sp., *Quercus* sp., *Tilia* sp., *Salix* sp., *Ulmus* sp., *Tilia* sp. and *Sorbus* sp. (Meijerman and Ulenberg, 2000; Zhang, 1994).
Minor hosts: *Malus* sp. (Anon., 1965); *Prunus* sp., *Pyrus* sp. (Meijerman and Ulenberg, 2000; Zhang, 1994).

Archips fuscocupreanus

A. fuscocupreanus is a polyphagous species, feeding on a range of fruit trees and deciduous trees and shrubs. It is recorded from 87 plants in 15 families, and is most abundant on *Malus*, *Pyrus* and *Morus* (CPC, 2007). *Pyrus communis*, *Pyrus* sp. (CPC, 2007; Meijerman and Ulenberg, 2000).

Archips rosana

A. rosana is polyphagous, feeding mainly on fruit trees and deciduous trees and shrubs (CPC, 2007).
Major hosts: *Malus domestica*, *Pyrus communis* (CPC, 2007).

Archips xylosteanus

A. xylosteanus primarily feeds on members of the Rosaceae. The following hosts are recorded: *Abies* (Zhang, 1994); *Calendula officinalis, Foeniculum, Malus domestica, Prunus armeniaca, P. avium, P. persica* (CPC, 2007); *Pyrus* (Zhang, 1994); *Quercus ilex, Q. robur, Rhododendron, Rosa canina, Solanum* (CPC, 2007); *Ulmus* (Bradley et al, 1973).

Plant parts affected

Leaves, buds, young fruit (Meijerman and Ulenberg, 2000).

Geographical distribution

Archips breviplicanus

Asia: China (Heilongjiang, Jilin), Japan, Korea, Russia (Byun et al, 2003; Hwang, 1974; Meijerman and Ulenberg, 2000).

Archips crataeganus

Asia: China (Byun et al, 2003; Sun et al, 1998; Zhang, 1994); Russia (Anon., 1965; Zhang, 1994); Korea (south); Japan (Byun et al, 2003).
Europe: Bulgaria, Italy, Turkey, United Kingdom (Zhang, 1994).

Archips fuscocupreanus

Asia: China (Heilongjiang, Liaoning) (Byun et al, 2003); Japan (CPC, 2007; Meijerman and Ulenberg, 2000); Russia, Korea (CPC, 2007; Meijerman and Ulenberg, 2000); USA (CPC, 2007).

Archips rosana

A. rosana occurs in Canada, USA and through much of Europe (CPC, 2007). In Asia it occurs in China (You et al, 1983; Zhang, 1994), Kazakhstan, Turkey (CPC, 2007).

Archips xylosteanus

Asia: China (Heilongjiang, North and Central) (Bradley et al, 1973; Byun et al, 2003); Japan (Bradley et al, 1973; Zhang, 1994).
Europe: Bulgaria, France, Germany, Lithuania, Poland, Romania, Sweden, Turkey (Zhang, 1994); Russia, United Kingdom (Bradley et al, 1973).

Hazard identification conclusion

Archips breviplicanus, Archips crataeganus, Archips fuscocupreanus, Archips rosana and *Archips xylosteanus* have been recorded on *Pyrus*, and are associated with the fruit of host plants. They are present in China and not known to be present in New Zealand, and are considered to be potential hazards.

10.4.2 Risk assessment

Entry assessment

Only the larvae of these *Archips* spp. are associated with the fruit of host plants. Since the larvae are only reported from young fruit, it is highly unlikely that they will be associated with *Pyrus* fruit at harvest. *A. breviplicanus* larvae may be present on more mature fruit. However they are surface feeders leaving scars on the fruit which would be detected during harvest and packing processes.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Archips breviplicanus, Archips crataeganus, Archips fuscocupreanus, Archips rosana* and *Archips xylosteanus* entering New Zealand with *Pyrus* fresh fruit from

China is negligible. As a result the risk estimate is negligible and they are not classified as hazards in the commodity. Therefore risk management measures are not justified.

Note that although these *Archips* spp. are not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, they remains a ‘regulated pest’. Therefore, if they are intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

There is little information on the distribution of these species in China.

10.5 *Carposina sasakii – peach fruit borer*

Scientific name: *Carposina sasakii* Matsumara, 1900 (Lepidoptera: Carposinidae)
Other relevant scientific names: *Carposina niponensis* Walsingham; *Carposina persicana* Fitch; *Cydia persicana* Sasaki.
Common names: peach fruit borer, peach fruit moth

10.5.1 Hazard identification

New Zealand status

Carposina sasakii is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Carposina sasakii is considered to be an important pest in the Far East. Newly-hatched larvae of *C. sasakii* bore into the core of fruit, feeding on the flesh and seeds, and remain there until fully developed (CPC, 2007; Ishiguri and Toyoshima, 2006). As the larvae develop, they move from fruit to fruit and their success in penetrating fruit relies on the species and cultivar of the fruit that they attack and on larval growth stage (CPC, 2007; Chang et al, 1977). As well as temperature, these factors affect the rate of larval development (Chang et al, 1977). Larvae overwinter in thick cocoons in the soil, 1–2 metres from the trunk of the host plant, and once the temperature rises above 15°C, they come up to the surface and pupate in new, light cocoons (Komarova, 1981). Larvae have been also been found overwintering in fruit in storage (CPC, 2007). Adults are nocturnal and rest on leaves during the day (Komarova, 1981). Eggs (between 44 and 227) are laid in or near the calyx of fruit (Chang et al, 1977; CPC, 2007; Hwang, 1958). Oviposition location depends on the host: in apples it occurs at the calyx end of the fruit, whilst on dates it occurs at the stalk end (Hua and Hua, 1995).

In China, *C. sasakii* is an important pest of pome and stone fruit (Chang et al, 1977). There is one generation, followed by a partial second generation in the Liaoning and Shandong provinces if warm conditions persist (Chang et al, 1977; Hwang, 1958). Life stages overlap, with the overwintered larvae leaving the soil from the end of May to mid-July. Eggs remain on the fruit from June until mid-September, and fully-fed larvae of the first generation leave the fruit from mid-July. In Shaanxi province, there is one generation per year. Adults are present on pears from late July to late September, and larvae are present in pear fruit from early August to early September (Hua and Hua, 1995).

Chang and others (1977) observed that young pear fruit were more resistant to infestation by *C. sasakii*, but became more susceptible as the skin ripened and became easier to penetrate. As a consequence, the survival rates of second generation larvae were higher than those of the first generation.

In Korea, the first generation of *C. sasakii* adult moths emerge 12 days after pupation and flying begins in late May to early June and ends around mid-June. The second generation of adults fly from mid-August to early September (Hwang, 1958). Kim and Lee (2002) state that the seasonal occurrence of adult *C. sasakii* in Korea is very complex and unpredictable both within and between years.

Hosts

The hosts of *C. sasakii* are in the Rosaceae and include:

Aronia arbutifolia, *Chaenomeles japonica*, *Cornus mas* (CPC, 2007); *Crataegus* spp., *Cydonia oblonga* (Zhang, 1994)*; Malus domestica, Malus micromalus, Malus toringo, Phoenix dactylifera, Prunus armeniaca, Prunus domestica, Prunus dulcis, Prunus mume, Prunus persica Prunus salicina, Pyrus* sp. (Komarova, 1981; Zhang, 1994); *Rosa* sp., *Sorbus aucuparia, Ziziphus sativa*; *Ziziphus jujube* (CPC, 2007); *Pyrus communis* (CPC, 2007); *Pyrus pyrifolia* (AQSIQ, 2007; CPC, 2007); *Pyrus bretschneideri* (AQSIQ, 2007).

Plant parts affected

Fruit (CPC, 2007; Ishiguri and Toyoshima, 2006).

Geographical distribution

Asia: China (Beijing, Guangdong, Hebei, Heilongjiang, Henan, Jiangsu, Liaoning, Ningxia, Shandong, Shantung, Shaanxi, Shanxi, Zhejiang) (CPC, 2007; Chang et al, 1977; Hang et al, 1976; Hwang, 1958; Kim et al, 2000; Zhang, 1994); Japan (Toshima and Honma, 1961; Ishiguri and Toyoshima, 2006); Korea (Kim and Lee, 2002).
Europe: Russia (Kim et al, 2000; Zhang, 1994).

Hazard identification conclusion

Carposina sasakii has been recorded on *Pyrus*, and is associated with the fruit of host plants. It is present in China. It is not known to be present in New Zealand, and is considered to be a potential hazard.

10.5.2 Risk assessment

Entry assessment

Carposina sasakii is present in some of the main pear growing regions of China.

The larvae feed within the fruit of host plants, including *Pyrus*. There can be several larvae in one fruit (CPC, 2007). Fully-developed larvae are 13 mm in length and orange-red in colour; newly hatched larvae are orange-red also, but in between these stages, larvae are milky-white (CPC, 2007). Although larvae are small, they are visually detectable on the outer surface of the fruit due to their bright colouration, at neo-natal and mature stages. Once inside, the damage shown on the outer surface of the fruit varies depending on the extent of damage on the inside of the fruit. Larvae can survive for long periods within stored fruit (CPC, 2007).

Eggs are 0.3 mm in diameter, elliptical and yellow-brown and are normally laid in the calyx of the fruit (CPC, 2007). Since eggs are minute, and are sometimes laid individually, there is high likelihood that eggs of *C. sasakii* would be undetected through the harvest and packing processes. The egg stage lasts for 6–8 days with the optimum conditions being 25ºC with 75–85% RH (Komarova, 1981). The lower threshold for development of eggs is 11ºC (Komarova, 1981).

Transit time from China to New Zealand by sea is approximately four weeks. It is likely that *C. sasakii* larvae present in the fruit will survive since they have been found overwintering in fruit in storage (CPC, 2007). It is less likely that any eggs will survive.

C. sasakii larvae are intercepted by USDA inspectors almost every year on fruit from Japan and Korea (CPC, 2007). Other *Carposina* spp. have been intercepted at the New Zealand border and there has been an interception of live Carposinidae on *Pyrus pyrifolia* from an unknown origin in 1994 (MAFBNZ, 2009).

Given that:

- *C. sasakii* occurs in many of the main pear growing areas of China;
- larvae and eggs are likely to be present on/in fruit at harvest time;
- some infested fruit are likely to be detected and discarded during the harvest and packing process;
- larvae are expected to survive shipment to New Zealand;

The likelihood of entry is considered to be high and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and often the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. The waste material generated would allow some *C. sasakii* larvae to disperse and find a suitable host. For example, if fruit containing larvae were disposed in a compost bin, under a Rosaceae host plant, the likelihood of larvae finding a host would be high. The major hosts of *C. sasakii* are *Malus*, *Prunus* and *Pyrus*, which are distributed widely throughout New Zealand, both in commercial orchards and in landscape and backyard plantings. Larvae pupate near the surface of the soil.

Given that:

- larvae are mobile, at least to some degree;
- host plants are widely distributed in New Zealand in both domestic and commercial situations;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

An emerging adult would need to find an individual of the opposite sex to establish a population. On average, female adults live for 13 days and male adults 16 days at 23 °C in laboratory conditions. Adults are active when temperatures exceed 11 ºC (Ishiguri and Shirai, 2004). *C. sasakii* adults normally fly relatively short distances with a maximum dispersal distance of 225 m reported in one study in China (CPC, 2007). This would be sufficient for at least some hatching adults to find a mate and a suitable host. Multiple larvae entering in fruit and production of sex pheromones would be expected to increase the likelihood of adults being able to find a mate. Females fly to new locations to find fruit on which to oviposit, as eggs are only laid on fruit (Ishiguri and Shirai, 2004).

Although *C. sasakii* prefers warm climates (Li et al, 2006), it has established successfully in Asian countries where there are cool-temperate climates. It is considered unlikely that climate would be a barrier to its establishing in New Zealand. In addition, *C. sasakii* overwinters during its larval stage, and the lower threshold temperature for development into a pupa is 15ºC, so it would be able to hibernate before conditions became unfavourable (in autumn or winter, depending in which region of New Zealand it is situated), and resume feeding once conditions were favourable (spring or summer).

Since Rosaceae grow wild, and are widely cultivated and fruit-bearing in summer, these factors would increase the chance of development and establishment in New Zealand. In addition, there are numerous species of Rosaceae that have been cultivated in New Zealand.

Given that:

- *C.sasakii* reproduces sexually, but multiple larvae in a fruit will increase the likelihood of mating;
- hosts are widely distributed;
- climate is unlikely to be a barrier to establishment;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

The introduction of *C. sasakii* could have a severe economic impact on commercial fruit-growing (CPC, 2007). *C. sasakii* prefers Rosaceae hosts, particularly pears, apples and stonefruit (CPC, 2007; Hwang, 1958; Komarova, 1981). It is considered one of the most important pests of these fruit in the Far East. On apples in Japan, Korea and China, it may cause heavy losses if not controlled (CPC, 2007). Hwang (1958) observed damage to a third of the apple crop in Liaoning province, caused by a mixed population of *C. sasakii* and *Cydia inopinata*. Damage to pears can reach 100% (CPC, 2007).

New Zealand has a large pipfruit industry, consisting of apples and pears, and infestation by *C. sasakii* could lead to serious losses in the industry. Furthermore, since it is currently only found in Asia and a small part of Europe, if the pest was to establish in New Zealand, there could be a high impact on market access, particularly the export of New Zealand pomes and stonefruit and other Rosaceae to USA or Australia.
The potential economic impact is considered to be high.

Environmental consequences

Host plants of *C. sasakii* are widely distributed throughout New Zealand. These plants include members of the genus *Malus, Prunus, Pyrus* and *Rosa* (Webb et al, 1988). The potential host range in New Zealand includes a number of native species from the Rosaceae family that may be susceptible to *C. sasakii* infestation, such as *Acaena, Geum, Potentilla* and *Rubus*. However *Rubus* occurs overseas within the range of *C. sasakii* and is not recorded as a host, while *Acaena, Geum* and *Potentilla* lack fleshy fruit (Webb et al, 1988), so the native members of the Rosaceae may not act as hosts.
The potential environmental impact is uncertain but likely to be low.

Human health consequences

There are no known human health impacts.

Risk estimation

Carposina sasakii has a high likelihood of entry, moderate likelihood of exposure, and a moderate likelihood of establishment in New Zealand. The potential economic impact within New Zealand is high. *As a result the risk estimate for C. sasakii is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

Due to the lack of information regarding survival rates of *C. sasakii* eggs at low temperatures, there is uncertainty about whether they are able to survive refrigerated shipment from China.

10.5.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest-free area

C. sasakii is widespread in China, and pest-free area status is not likely to be a viable risk management option. The main growing area for *Pyrus* sp. nr. *communis* is Xinjiang Autonomous Region. *C. sasakii* has not apparently been reported from Xinjiang and pest free area status may be a viable option for pears from this area if its absence can verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

In-field control and surveillance

C. sasakii produces sex pheromones. This may facilitate targeted surveys of export orchard areas to detect its presence. Detection in the surveillance programme would indicate the failure of in-field control and any fruit from an infested area should not be permitted entry to New Zealand.

Bagging of fruit

Adults of *C. sasakii* are relatively large, with a wingspan of 15–19mm. The practice of bagging individual fruit is likely to prevent adult females from laying eggs on the fruit surface or the calyx. However there is a period of up to four weeks from fruit set before fruit are bagged, during which eggs could be laid. *Pyrus* sp. nr. *communis* are not bagged.

Phytosanitary inspection prior to export

Eggs are 0.3 mm in diameter, elliptical and yellow-brown and are normally laid in the calyx of the fruit; they may not be detected by visual inspection. Fully-developed larvae are 13 mm in length and orange-red in colour; they are obvious to the naked eye on the outer surface of the fruit. Larvae are internal feeders and the damage shown on the outer surface of the fruit varies depending on the extent of damage on the inside of the fruit. It is likely that visual inspection would detect some but not all infested fruit.

Cold treatment

The lower temperature threshold for eggs is 11ºC; larvae and pupae are able to overwinter, and have been known to do so in fruit in storage (CPC, 2007). The normal cool-store temperature of 0–1°C is likely to kill any eggs, but will not mitigate the risk of live larvae reaching New Zealand.

Fumigation

The EPPO recommend that fruit from host plants of *C. sasakii* in the Far East should be subject to strict phytosanitary measures and refer to a fumigation schedule published in Russia of 23g/m^3 at >1°C for over-wintering larvae and 17–20 g/m^3 for summer generation larvae (EPPO, undated). However methyl bromide fumigation is considered damaging to the types of fruit for which access is being sought (see Chapter 4).

A combination of fruit bagging and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

10.6 *Choristoneura longicellanus* – *common apple leafroller*

Scientific name: *Choristoneura longicellanus* (Walsingham, 1900) (Lepidoptera: Tortricidae)
Other relevant scientific names: *Hoshinoa longicellana* (Walsingham); *Tortrix longicellana* Walsingham
Common name: common apple leafroller

10.6.1 Hazard identification

Taxonomy

This species was known as *Hoshinoa longicellana,* but is now described as regarded to be *Choristoneura longicellanus* (Brown, 2005). Many of the references used in this risk analysis use the name *Hoshinoa longicellana*.

New Zealand status

Choristoneura longicellanus is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Choristoneura longicellanus is a pest of fruit trees including apple, chestnut, persimmon, pear and plum (Meijerman and Ulenberg, 2000; Nakayama, 1937a). In the spring, larvae feed in unfolding buds, spin a few young leaves together and cut petioles of inner leaves. They feed on the lower surface of leaves under linear webs along major leaf veins (Meijerman and Ulenberg, 2000). In Japan, first generation larvae feed mostly on leaves, whilst some second and third generation larvae may feed on both leaves and fruit. The resulting scars on the fruit affect their marketability Nakayama (1937a).

There are two generations a year in China. Larvae overwinter in dead leaves, wounds on branches or between branches. Adult moths emerge in May-June for the first generation and August-September for the second generation. Eggs are laid on the surface of leaves (Byun et al, 2003).

In the apple orchards of Japan, adults emerge in June, July and August, from the first, second and third generations, respectively. Oviposition occurs within a few days and egg masses containing up to 250 eggs are deposited on the leaves of the host plant (Nakayama, 1937a). Larvae live between 16 and 21 days before they pupate by spinning a cocoon within the leaves of the host plant. Larvae are active, crawling as well as dispersing longer distances on silken threads (Nakayama, 1937a). The pupal stage lasts seven to ten days. Third generation larvae overwinter among withered leaves attached to the host plant or in fallen leaves (Nakayama, 1937a).

Hosts

Castanea crenata, *C. pubiner* (Meijerman and Ulenberg, 2000); *Gossypium* spp. (Kambe, 1934); *Malus pumila* (Nakayama, 1937a); *Morus* sp., *Prunus × yedoensis*, *Pyrus simoni* (= *P. ussuriensis*), *Quercus* spp., *Rosa multiflora* (Meijerman and Ulenberg, 2000); *Pyrus pyrifolia, P. bretschneideri* (AQSIQ, 2007); *Pyrus* sp. (Byun et al, 2003).

Plant parts affected

Leaves and fruit (Nakayma, 1937a).

Geographical distribution

Asia: China (Byun et al, 2003; Zhang, 1994); Japan (Meijerman and Ulenberg, 2000; Nakayama, 1937a); Korea (Kambe, 1934; Meijerman and Ulenberg, 2000; Piao et al, 2006); Russia (Meijerman and Ulenberg, 2000).

Within China, it is recorded in Heilongjiang, Inner Mongolia, Shandong, Anhui, Hubei, Hunan, Jiangxi, Jiangsu, Sichuan and Yunnan (Byun et al, 2003; Meijerman and Ulenberg, 2000).

Hazard identification conclusion

Choristoneura longicellanus has been recorded on *Pyrus* and on the fruit of host plants. It is present in China and is not known to be present in New Zealand. It is considered a potential hazard.

10.6.2 Risk assessment

Entry assessment

The adults, pupae and eggs of *C. longicellanus* are not associated with the fruit of host plants. Second and third generation larvae may feed on fruit (Nakayama, 1937a). The resulting damage is likely to be superficial and external, and detectable during the harvest and packing processes. Fully-grown larvae, the stage most likely to be present at the time of harvest, are 23 mm in length and yellowish-green, with a brown-black head (Meijerman and Ulenberg, 2000), and, in conjunction with attached leaves and webbing, are likely to be noticed at harvest and either dislodged or discarded during the picking process. Furthermore, larvae are mobile and it is unlikely that they would remain on harvested fruit.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *C. longicellanus* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for C. longicellanus is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *C. longicellanus* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a ‘regulated pest’. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

There is little information available on the biology and behaviour of *C. longicellanus* on pears in China. Much of this assessment relates to apples in Japan.

10.7 *Conogethes punctiferalis – yellow peach moth*

Scientific name:	*Conogethes punctiferalis* (Guenée, 1854) (Lepidoptera: Pyralidae)
Other relevant scientific names:	*Dichocrocis punctiferalis* (Guenée)
Common names:	castor seed caterpillar, castor borer, cone moth, durian fruit borer, maize moth, peach pyralid moth, Queensland bollworm, smaller maize borer, yellow peach moth

10.7.1 Hazard identification

New Zealand status

Conogethes punctiferalis is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Taxonomy

C. punctiferalis is a complex of at least two species (CPC, 2007) (accessed 04/02/2009). A polyphagous form that feeds on fruits from a number of plant families and an oligophagous form that feeds on leaves of Pinaceae have been noted in Japan (Konno et al, 1981). A similar situation has been noted in China (Chai and He, 1987). On the basis of morphological differences and other evidence, Honda and Mitsuhashi (1989) concluded that the fruit- and Pinaceae-feeding types of *C. punctiferalis* in Japan are discrete taxonomic species. However, they have not said which form should be named punctiferalis or whether a name is available for the other form (CPC, 2007). Fruit-feeding and pine-feeding types are not always distinguished in the literature (e.g. FAO, 2007). Therefore this assessment will refer to the species complex although it is unlikely that the Pinaceae-feeding type will be associated with this commodity.

Biology

Conogethes punctiferalis is indigenous to China (FAO, 2007). Infestations result in the stunting, scorching and dropping of fruit. *C. punctiferalis* has a relatively short life cycle of six weeks in the summer season. It usually has two to three generations per year (FAO, 2007). In southern China, it has five generations per year (Wang and Cai, 1997).

In China, the average lifespan of a first-generation adult female is ten days. In China and Japan, there are morphological differences between adults from larvae fed on fruit and Pinaceae (CPC, 2007). The populations on crops and fruit trees are borers and the larvae feed and pupate individually (Chai and He, 1987). The orange-yellow moth has a wing span of 2.5 cm and a number of conspicuous black spots on the wings and body (Astridge et al, 2005).
Both female and male moths feed on the nectar of the larval host plant and surrounding plants (CPC, 2007). Two to three days following mating, females lay twenty to thirty eggs singly on, or near, the surface of fruit, maize ear silk and tassels or seeds. Eggs are elliptical, about 2 mm and hatch in five to eight days (CPC, 2007; FAO, 2007). Newly hatched larvae crawl rapidly on the fruit surface and bore into the fruit within several hours. Larvae web the fruit together and feed on them and remain there until they pupate

(CPC, 2007). On maize, first-instar larvae feed on pollen and ear silk and bore into the stem and ear. The duration of the larval stage is about 15–18 days (CPC, 2007). The pupae are brown, 13 mm long and 4 mm wide, while adults are yellow and 12 mm long. Pupation occurs within cocoons or shelters of webbed frass and may occur inside the fruit or externally (Wu, 1995; Astridge et al, 2005; Patel and Gangrade, 1971; Singh et al, 2002) and lasts about 8 days (Gour and Sriramulu, 1992). Adults emerge from pupae at night. Most adults are active at night and they hide and remain still on the back of host leaves during the day (CPC, 2007).

C. punctiferalis overwinters as full grown larvae (Chai and He, 1987) and pupates in mid-winter, in shelters of webbed frass under bark, in stems and fruit (CPC, 2007; Astridge et al, 2005).

Hosts

C. punctiferalis is highly polyphagous, with recorded hosts in 16 families (Asteraceae, Bombacaceae, Caricaceae, Euphorbiaceae, Fabaceae, Malvaceae, Moraceae, Myrtaceae, Oxalidaceae, Poaceae, Pinaceae, Proteaceae, Rosaceae, Rutaceae, Sapindaceae and Zingiberaceae). The pine-feeding form, which is likely to be a separate species, is oligophagous and feeds on the young leaves of Pinaceae such as *Pinus* spp. and *Cedrus* spp. (e.g., Konno et al, 1981).

Recorded hosts include:
Abies sp. (Zhang, 1994); *Averrhoa carambola*, *Carica papaya* (CPC, 2007); *Castanea* spp. (FAO, 2007); *Caesalpinia bonducella*, *Cedrus deodara*, *Ceiba pentandra*, *Citrus* spp. (Zhang, 1994); *Curcuma longa* (CPC, 2007); *Durio* spp. (FAO, 2007); *Elettaria cardamomum* (CPC, 2007); *Flemingia* spp. (Zhang, 1994); *Gossypium* sp., *Helianthus annuus* (CPC, 2007); *Macadamia* spp. (FAO, 2007; Zhang, 1994); *Malus* sp. (Honda et al, 1988); *Morus alba* (CPC, 2007); *Nephelium lappaceum* (Zhang, 1994); *Pinus* spp. (FAO, 2007); *Pinus massoniana*, *Pinus parviflora* (Zhang, 1994); *Prunus* spp. (FAO, 2007); *Psidium guajava* (CPC, 2007); *Pyrus pyrifolia* (Lee et al, 2000; AQSIQ, 2007); *Pyrus bretschneideri* (AQSIQ, 2007); *Ricinus* spp. (Zhang, 1994); *Sorghum bicolor, Vitis vinifera, Zea mays, Zingiber officinale* (CPC, 2007).

Plant parts affected

Eggs are laid on the surface of the fruit and larvae feed on the surface of, and within, the fruit (CPC, 2007).

Geographical distribution

Asia: Brunei Darussalam, Cambodia (CPC, 2007); China (CPC, 2007; Zhang, 1994); India, Indonesia, Japan, Korea (DPR), Korea (Republic of), Laos, Malaysia, Myanmar, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam (CPC, 2007).
Oceania: Australia, Papua New Guinea (CPC, 2007).

Within China, *Conogethes punctiferalis* is recorded in Anhui, Fujian, Guangdong, Guangxi, Hebei, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Liaoning, Shaanxi, Shandong, Shanxi, Sichuan, Xizhang, Yunnan and Zhejiang (CPC, 2007).

Hazard identification conclusion

Conogethes punctiferalis has been recorded on *Pyrus*, and is associated with the fruit of host plants. It is present in China. It is not known to be present in New Zealand, and is considered to be a potential hazard.

10.7.2 Risk assessment

Entry assessment

C. punctiferalis is recorded in many provinces in China, but its prevalence in pear orchards is unknown. All life stages can be associated with fruit.

The adults of *C. punctiferalis* have a wingspan of 25 mm and are known to feed on the nectar and fruit of host plants (CPC, 2007; Kang et al, 2004). However, they are active only at night and hide on the backs of leaves during the day, and are unlikely to be associated with fruit during harvesting.

Eggs are 2–2.5 mm long and elliptical in shape. They are laid individually on the surface of the fruit. In China, *C. punctiferalis* has between two and five generations per year and the fullgrown larvae overwinter. This suggests eggs could be present at harvest time. Their small size means that they may not be detected during the harvest and packing processes.

Mature larvae are 25 mm long. They feed inside the fruit. Live larvae of *C. punctiferalis* have been intercepted twice at the New Zealand border (on capsicum in 2004 and on tomato in 2008); both shipments were from Australia (MAFBNZ, 2009). Dead larvae of *C. punctiferalis* have also been intercepted at the Canadian border on *Pyrus pyrifolia* (Lee et al, 2000). Pupae are 13mm long and 14 mm wide, and can be formed on or in the fruit. Larvae and pupae are more likely than eggs to be detected during harvest.

Given that:

- *C. punctiferalis* is recorded in many provinces in China, but its prevalence in pear orchards is unknown;
- adults are nocturnal and active fliers so are unlikely to be associated with fruit during harvesting;
- eggs, larvae and pupae may be associated with the fruit at the time of harvest;
- eggs are laid on the fruit surface but may not always be detected during a visual inspection due to their small size;
- larvae and pupae occur inside the fruit but may be detected during the harvest and packing process by the presence of entry holes and other damage to the fruit;
- a proportion of eggs, larvae or pupae of *C. punctiferalis* may survive shipping to New Zealand;
- live *C. punctiferalis* larvae have been intercepted at the New Zealand border on other pathways;

The likelihood of entry of Conogethes punctiferalis larvae is considered to be moderate and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and often the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. It is assumed that any *C. punctiferalis* larvae associated with imported fruit disposed of in this way would be able to pupate and emerging adults disperse. The moth is mobile and highly polyphagous. It is likely that any emerging adults would be able to find a suitable host.

Given that:

- uneaten fruit that contains eggs, larvae or pupae of *C. punctiferalis* may be discarded in compost heaps or the environment;
- eggs, larvae and pupae may continue or complete their development in the discarded waste;
- larvae are polyphagous, and acceptable hosts are likely to be widely available;
- *C. punctiferalis* adults are mobile and likely to find suitable host plants;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

Since eggs are laid singly, multiple infested fruit would need to be disposed of in fairly close proximity, and the associated organism complete its life cycle and develop into an adult. Two adults of opposite sex would need to locate each other and mate. *C. punctiferalis* reproduces sexually and females release sex pheromones to attract males (CPC, 2007). After mating, a host plant needs to be located to deposit eggs. The host range of *C. punctiferalis* covers many plants from important fruit species to arable crops, and it is very likely to be able to find suitable hosts throughout New Zealand.

Warm conditions favour the development of *C. punctiferalis* larvae, by reducing the time required for development (Kang et al, 2004). However, it occurs in Asian countries like Japan and China where there are areas with cool-temperate climates. *C. punctiferalis* overwinters in the larval stage; therefore it would have the ability to hibernate once conditions become unfavourable. The lifecycle of the moth and its current distribution, suggest that it would be likely to be able to establish in New Zealand.

Although *C. punctiferalis* is seen as a minor and infrequent pest in Australia, it has been identified as a major and frequent pest of economic importance in the warm wet tropics of regions of north Queensland, especially for rambutan and durian. It is generally more frequent in years with continuously wet summers (Astridge et al, 2005; Astridge, 2006). This suggests that it may be more suited to warmer, wetter areas such as the northern regions of New Zealand.

Given that:

- *C. punctiferalis* reproduces sexually and at least one individual of each sex would be required to start a reproducing population;
- females employ pheromones to attract males which increases the chance of finding a mate;
- *C. punctiferalis* is polyphagous, and acceptable hosts are widely available in modified environments in New Zealand;
- at least parts of New Zealand may have a climate suitable for *C. punctiferalis,* particularly the warmer, wetter northern regions;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

C. punctiferalis is an economically important pest in Australia. The larvae cause extensive damage to developing and mature fruit by feeding on the fruit surface and boring into the fruit. It reportedly destroys 90% of rambutan fruit clusters if left uncontrolled (Astridge, 2006). Multiple generations per year can result in high populations. *C. punctiferalis* can cause significant damage to stems, fruit and seeds of host plants (FAO, 2007). It is an important pest of peaches in southern China and of apples in northern China (CPC, 2007), and contributes up to 25% of chestnut crop loss (FAO, 2007). It is also a serious pest of chestnut in Korea (Kang et al, 2004). Excretions from *C. punctiferalis* have a high sugar content which covers the fruit surface, attracting secondary insect pests and diseases that further damage fruit (CPC, 2007). It is polyphagous; major hosts are in the Rosaceae which contains several crops of economic importance in New Zealand. If its distribution in New Zealand is limited the scale of economic impacts would be reduced.

C. punctiferalis appears to be currently confined to Australia and (mostly east) Asia. If it were to establish in New Zealand, there could be an impact on market access, including the export of New Zealand pome and stone fruit. There may also be adverse effects on market access if the pipfruit industry has to change from its current low chemical production regime.

Should the pine-feeding form of *C. punctiferalis* reach New Zealand it could attack *P. radiata*, an important timber crop grown widely throughout the country. However, this is regarded as a different form (or even species) of *C. punctiferalis* from that associated with fruit. Therefore it is unlikely to be associated with this pathway.

The potential economic consequences are considered to be moderate.

Environmental consequences

C. punctiferalis is highly polyphagous and several of the families in which it has hosts also have New Zealand native members (e.g. Euphorbiaceae, Myrtaceae, Rutaceae) including endemic species (e.g., *Syzygium maire*) and genera (e.g., *Lophomyrtus*, *Neomyrtus*). The impact on native flora is uncertain but cannot be ruled out.

In addition, many exotic plant species in the same families as known hosts of *C. punctiferalis* are found in domestic gardens and parks in New Zealand, or are naturalised in the wild. Damage to the former might be of concern to gardeners, and colonisation of naturalised species in the wild could assist dispersal and provide reservoirs.

The potential environmental consequences are considered to be moderate

Human health consequences

There are no known human health hazards caused by *C. punctiferalis*.

Risk estimation

Conogethes punctiferalis has a moderate likelihood of entry, moderate likelihood of exposure and low likelihood of establishment in New Zealand. The potential economic impact within New Zealand is moderate. *As a result the risk estimate for C. punctiferalis* *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There is uncertainty around the prevalence of *C. punctiferalis* in pear orchards, how well it would survive in transit from China, and the suitability of the New Zealand climate for the development of *C. punctiferalis.* Moreover, because *C. punctiferalis* is a complex of species, there is some uncertainty about its biology and its potential impact.

10.7.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below Their effect in managing the risk posed by this organism is assessed.

Pest free area

C. punctiferalis is widespread in China, and pest-free area is not likely to be a viable option for *P. pyrifolia* and *P. bretschneideri* fruit. The main growing area for *Pyrus* sp. nr. *communis* is Xinjiang Autonomous Region. *C. punctiferalis* has not apparently been reported from Xinjiang and pest free area status may be a viable option for pears from this area if its absence can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

In-field control and surveillance

C. punctiferalis produces sex pheromones. This may facilitate targeted surveys of export orchard areas to detect its presence. Detection in the surveillance programme would indicate the failure of in-field control and any fruit from an infested area should not be permitted entry to New Zealand.

Bagging of fruit

C. punctiferalis adults are 12 mm long (CPC, 2007). Bagging of fruit is likely to prevent adult *C. punctiferalis* from laying eggs on the surface of fruit. However there is a period of up to four weeks from fruit set before the fruit are bagged, during which eggs could be laid. Eggs hatch 5–18 days after laying and larvae pupate after a further 15–18 days. It is assumed that any eggs laid on fruit prior to the fruit being bagged would complete their development to adulthood prior to harvest of the fruit, making bagging an effective measure. *Pyrus communis* pears are not usually bagged because of the effect on fruit ripening. No records have been found for *C. punctiferalis* on this species.

Phytosanitary inspection prior to export

The egg, larval and pupal stages are associated with fruit. Eggs are white, 2.0–2.5mm in diameter and are likely to be visible to the naked eye. Larvae are internal feeders. Since mature larvae are relatively large it is assumed that there would be external evidence of infestation. Infestations can also result in fruit drop, or stunting and scorching of fruit: such fruit would be likely to be detected. *C. punctiferalis* excretions, which cover the fruit surface and have a high sugar content, attract other insect pests and diseases which damage fruit and will result in a greater likelihood of detection. Pupae occur on the surface of the fruit and are likely to be visible.

Cold treatment

C. punctiferalis overwinter as mature (fifth-instar) larvae in host stems or fruit or under the bark of fruit trees. Cold treatment is unlikely to mitigate the risk of live larvae entering New Zealand. The USA has two treatment schedules against *C. punctiferalis* on apples from Japan or Korea. They both consist of 40 days cold treatment (1.11 °C or below) followed by a methyl bromide fumigation of at least 0.5 hours (USDA, 2008a). Since Asian pears are liable to be damaged by methyl bromide fumigation this is unlikely to be a viable option.

A combination of fruit bagging and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

10.8 *Cydia funebrana – plum fruit moth*

Scientific name: *Cydia funebrana* Treitschke (Lepidoptera: Tortricidae)
Other relevant scientific names: *Grapholita funebrana* (Treitschke); *Grapholitha funebrana* Treitschke
Common name: plum fruit moth

10.8.1 Hazard identification

New Zealand status

Cydia funebrana is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Cydia funebrana is considered an economic pest of stonefruit throughout Europe. It has 1–3 generations per year depending on the latitude and climatic conditions. The generations often overlap. Eggs are laid singly or in small groups on the fruit surface. Larvae bore into the fruit after hatching and seal the entrance hole with silk. Larvae can move from one fruit to another. There are three instars. They can cause premature ripening and fruit drop. Pupation depends on host ripening and temperature. Adults overwinter (Venette et al, 2003).

Hosts

C. funebrata feeds primarily on stone fruits (*Prunus* spp.). Secondary hosts are reported to include *Malus domestica*, *Malus sylvestris*, *Juglans regia*, *Castanea Sativa* and *Pyrus communis* (Venette et al, 2003).

Plant parts affected

Fruit (Venette et al, 2003).

Geographical distribution

C. funebrata occurs in many countries in Asia and Europe as well as Algeria and Argentina (CPC, 2007).

Within China it is reported from Jilin and Liaoning Provinces (CPC, 2007).

Hazard identification conclusion

Cydia funebrana has been recorded on *Pyrus communis* and is associated with the fruit of the host plant. It is recorded in China. It is not known to be present in New Zealand, and is considered to be a potential hazard.

10.8.2 Risk assessment

Entry assessment

Pyrus communis has been reported as a secondary host of *Cydia funebrana* in an assessment by Venette and others (2003). Saringer and Deseo (1968) demonstrated this association in experiments in Hungary to determine what fruit might be used in circumstances where almost total fruit fall occurs on plum due to attack by other tortricid moths. However mortality of the larvae and pupae developing from eggs in these experiments was high – 81% on ripe pears and 97% on unripe pears.

Eggs, larvae and pupae may be associated with fruit, although whether they are present at harvest will depend on the timing of harvest in relation to the population dynamics of the population involved.

The larval stage of *C. funebrana* can be associated with the fruit of *Pyrus*. The larvae are internal feeders but the entry and exit holes are likely to be readily visible on the surface of the fruit due to the silk and gum seal.

Given that:

- *Pyrus* is a secondary host and only appears to be infested when fruit of its main hosts are not available, its prevalence in pear orchards is assumed to be low;
- some larvae may have left the fruit, depending on the time of harvest;
- larvae and pupae appear to have low survival rates in *Pyrus* fruit;
- at least some infested fruit will ripen prematurely or fall from the tree and will not be harvested;
- infested fruit remaining on the tree are likely to be detected during the harvest and packing process by the silk and gum surrounding entry holes;

The likelihood of entry is considered to be negligible.

Risk estimation

Cydia funebrana has a negligible likelihood of entry. *As a result the risk estimate for C. funebrana is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *Cydia funebrana* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

There is little information on the association between *Cydia funebrana* and its minor hosts. It is assumed that it will only infest *Pyrus* spp. when fruits of its favoured hosts are not available.

10.9 *Cydia inopinata – Manchurian fruit moth*

Scientific name: *Cydia inopinata* Heinrich (Lepidoptera: Tortricidae)
Other relevant scientific names: *Cydia prunifoliae* (Kozhanchikov); *Grapholita inopinata* (Heinrich); *Grapholitha inopinata* Heinrich; *Laspeyresia inopinata* Heinrich, 1928; *Laspeyresia prunifoliae* (Kozhanchikov)
Common name: Manchurian fruit moth

10.9.1 Hazard identification

New Zealand status

Cydia inopinata is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Kolmakova (1965) considered that *C. inopinata* was the most serious pest of apple in Russia. Newly-hatched larvae of *Cydia inopinata* feed on the skin of apples and then bore into the fruit to attack the seeds (Kolmakova, 1958). Leaves are also damaged by the egg masses that are laid on them. Hwang (1958) observed damage to a third of the apple crop in Liaoning province, China caused by a mixed population of *C. inopinata* and *Carposina sasakii*.

In Russia, there is one generation per year. Eggs are laid on leaves at the end of June and on fruit in early July. Eggs hatch in five to seven days and after 35–40 days of feeding, the larvae migrate to the soil and pupate in cocoons in dry leaves (Kolmakova, 1958). Larvae leave the fruit in late August and September in Russia (Meijerman and Ullenberg, 2000). Adults emerge in early June, when apple flowering begins, and remain until August (late summer) (Kolmakova, 1965). Females lay an average of 145 eggs.

Further south there are two generations, flying in May-June and August-September in Manchuria (north-eastern China) and slightly earlier in Guangdong. Larval development is correspondingly faster, averaging 16 days for the first generation and 27 days for the second (CPC, 2007).

Hosts

Apples are the main host. Pears and quince are reported to be minor hosts (CPC, 2007). **Rosaceae (Subfamily Maloideae/Pomoideae):** *Cydonia oblonga* (CPC, 2007); *Malus domestica* (Gibanov and Sanin, 1971; Kolmakova, 1958; Kolmakova, 1965); *Malus pallasiana, Pyrus communis* (CPC, 2007); *Pyrus pyrifolia* (AQSIQ, 2007; CPC, 2007); *Pyrus bretschneideri* (AQSIQ, 2007).

Plant parts affected

Fruit, seeds, leaves (Kolmakova, 1958).

Geographical distribution

Asia: China (Guangdong, Heilongjiang, Jilin, Liaoning, Shandong), Japan, Korea (CPC, 2007; Zhang, 1994).
Europe: Russia (Kolmakova, 1965); Eastern Siberia, Russian Far East (CPC, 2007).

Hazard identification conclusion

Cydia inopinata has been recorded on *Pyrus communis, P. pyrifolia* and *P. bretschneideri* and is associated with the fruit of the host plant. It is recorded in China. It is not known to be present in New Zealand, and is considered to be a potential hazard.

10.9.2 Risk assessment

Entry assessment

Pupae and adults are not associated with the fruit of host plants. Eggs are laid from the end of winter to early spring and would not be associated with mature fruit.

The larval stage of *C. inopinata* is associated with the fruit of *Pyrus*. The larvae are internal feeders and are likely to be quite small as a single, fully-grown larva is small enough to inhabit a seed coat of an apple (Lopatina, 1978). They may not be detected during the harvest and packing process since they feed inside the fruit, although the exit holes are readily visible on the surface of the fruit (Meijerman and Ullenberg, 2000).

AQSIQ (2007) describe *C. inopinata* as occurring frequently in association with *Pyrus pyrifolia and P. bretschneideri.* Whether larvae are present in harvested fruit will depend on the timing of harvest in relation to the time at which the larvae leave the fruit to pupate.

Since the larvae are the over-wintering lifestage, it is assumed they would survive transport to New Zealand.

Given that:
- larvae feed inside fruit and may not be detected at harvest;
- some larvae may have left the fruit, depending on the time of harvest;
- larvae are likely to survive transfer to New Zealand;

The likelihood of entry is considered to be moderate and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and often the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. *C. inopinata* could survive as larvae inside fruit and exit on disposal to pupate in the soil or plant debris. Adult moths could then disperse to nearby hosts. *Pyrus* and *Malus* species are widely grown in New Zealand in commercial and domestic situations.

Given that:
- larvae are mobile, at least to some degree;
- host plants are widely distributed in New Zealand in both domestic and commercial situations;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

Since *C. inopinata* reproduces sexually, multiple larvae would need to enter and pupate in the same area, in order for an emerging adult to find an individual of the opposite sex and establish a population. Up to 15 eggs are laid on a single fruit in the Russian Far East (Lopatina, 1978). Normally there is only one larva in each fruit but up to five have been recorded (Meijerman and Ulenberg, 2000). The production of sex pheromones may assist in finding a mate. *C. inopinata* has a limited host range but *Pyrus* and *Malus* species are widely grown in New Zealand. Its distribution in Russia suggests that it is cold-tolerant, and establishment is unlikely to be inhibited by the New Zealand climate.

Given that:

- *C. inopinata* reproduces sexually, and multiple larvae in a fruit are unlikely;
- the host range is limited but hosts are widely distributed;
- climate is unlikely to be a barrier to establishment;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

C. inopinata is likely to cause production losses in apple and pear orchards. Since the larvae infest fruit internally they would be difficult to control. An additional fruit-boring insect in New Zealand could increase costs for growers of pipfruit, particularly apples (the major host).

C. inopinata appears to be currently confined to Asia and eastern Europe. If the pest were to establish in New Zealand, there could be an impact on market access, including the export of New Zealand pome and stone fruit. There may also be adverse effects on market access if the pipfruit industry has to change from its current low chemical production regime.
The potential economic impact within New Zealand is considered to be moderate to high.

Environmental consequences

C. inopinata has a narrow host range. All the recorded hosts are in the subfamily Pomoideae of the Rosaceae family (*Pyrus*, *Malus* and *Cydonia*). There are no native plants in this group and environmental consequences are unlikely.

Human health consequences

There are no known human health issues for this moth.

Risk estimation

Cydia inopinata has a moderate likelihood of entry and exposure and low likelihood of establishment, and is likely to have a low to moderate economic impact in New Zealand. *As a result the risk estimate for C. inopinata is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

No information was found on the biology of *Cydia inopinata* on *Pyrus* fruit. This assessment is based on information relating to its lifecycle on apples.

10.9.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest-free area

C. inopinata is widespread in eastern China. If its absence from the western province of Xinjiang can be verified in accordance with ISPM No. 4 (2006) (see section 4.2) then pest free area status may be an appropriate measure for some pears, particularly *Pyrus* sp. nr. *communis*.

In-field control and surveillance

C. inopinata produces sex pheromones. This may facilitate targeted surveys of export orchard areas to detect its presence. Detection in the surveillance programme would indicate the failure of in-field control and any fruit from an infested area should not be permitted entry to New Zealand.

Bagging of fruit

The practice of bagging individual fruit is likely to prevent adults and larvae from accessing the fruit surface. However there is a period of up to four weeks from fruit set before the fruit are bagged, during which eggs could be laid. This would not be an issue for fruit from areas where *C. inopinata* has two generations a year. *Pyrus* sp. nr. *communis* are not bagged.

Phytosanitary inspection prior to export

Larvae are internal, but conspicuous holes are made on the sides of fruit, which are visible to the naked eye. A thorough inspection is likely to detect the presence of this insect.

Cold treatment

The insect is probably tolerant of temperatures below freezing as it is present in Russia and Siberia so this is unlikely to be an effective option.

A combination of fruit bagging and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

10.10 *Euproctis chrysorrhoea – brown-tail moth*

Scientific name: *Euproctis chrysorrhoea* (Linnaeus, 1758) (Lepidoptera: Lymantriidae)
Other relevant scientific names: *Liparis chrysorrhoea* Linnaeus;
Common name: brown-tail moth

10.10.1 Hazard identification

New Zealand status

Euproctis chrysorrhea is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Larvae of *Euproctis chrysorrhoea* are polyphagous and feed on leaves of several hardwood trees and shrubs, including fruit trees. They may completely defoliate the host (Keimer, 1989).

There is one generation per year. In the USA, the larval stage lasts from August to June. Nests built in autumn house colonies of 25–400 larvae and are made of white silk wrapped around single leaves (Maine DOC, 2000). In spring, when temperatures reach 12–15 °C (Keimer, 1989).In Russia, the larvae skeletonise leaves while in their "nests", and pupate at the end of May on the trunk or crown of the host plant. Adults fly from the end of June until the beginning of August and are nocturnal. Oviposition takes place on the underside of the leaves, with eggs laid in masses of 200–500 leaf (Lyashenko, 1986). In Switzerland, *E. chrysorrhoea* is an important pest of fruit trees, including pomes. Larvae feed on leaves, buds and flowers during the day, returning to their nest (of 15–50 larvae) at night. In high populations, once the larvae have defoliated their host plant, they drop down to surrounding low-lying plants to feed on their leaves (Keimer, 1989). Keimer (1989) remarks that it is possible that the pests may attack the skin of apples and pears. Auersch (1971) states "in 1970, young larvae of *Euproctis chrysorrhoea* were observed attacking pear fruit for the first time".

E. chrysorrhoea is periodically a major urban pest in the United Kingdom. High populations cause severe defoliation of a range of plants in urban areas; and urticating hairs of larvae are highly irritating to humans (Cory et al, 2000). Defoliation of tree and presence of nests are clear symptoms (Keimer, 1989).

Hosts

Crataegus monogyna (USDA, 2008b); *Malus* sp. (Zhang, 1994); *Myrica* sp. (USDA, 2008b); *Prunus* spp. (CPC, 2007); *Prunus avium* (Kagan and Lewartowski, 1978; USDA, 2008b); *Pyrus* sp. (Zhang, 1994); *Pyrus communis* (CPC, 2007; Auersch, 1971); *Quercus* sp. (Lyashenko, 1986; USDA, 2008b); *Rosa* sp., *Salix* sp., *Ulmus* sp., *Vitis* sp. (Zhang, 1994).

Geographical distribution

E. chrysorrhea occurs throughout much of Asia, Europe, Canada, USA and northern Africa (CPC, 2007).

Within China, it has been recorded as having a limited distribution in Heilongjiang (CPC, 2007).

Hazard identification conclusion

Euproctis chrysorrhoea has been recorded on *Pyrus* fruit, it is present in China and it is not known to be present in New Zealand. It is considered to be a potential hazard on the *Pyrus* fruit from China pathway.

10.10.2 Risk assessment

Entry assessment

E. chrysorrhoea larvae are the only life-stage likely to be associated with fruit. They are associated primarily with the leaves and to a lesser extent the flowers of the host plant, although it has been reported feeding on the fruit of apples and pears. The presence of *E. chrysorrhoea* larvae on a tree is very evident from the extensive defoliation and the presence of nests. Furthermore the larvae are quite large. It is likely that any larvae that are present on fruit at the time of harvest would be detected during the harvest and packing processes.

The distribution of *E. chrysorrhoea* within China is not known but appears to be limited.

Taking account of these factors, *the likelihood of entry is considered to be negligible.*

Risk estimation

Euzophera pyriella has a negligible likelihood of entry. *As a result the risk estimate for E. pyriella is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *Euzophera pyriella* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

There is little information available on the distribution and prevalence of *E. chrysorrhoea* in pear orchards in China.

10.11 *Euzophera pyriella – pyralid moth*

Scientific name: *Euzophera pyriella* Yang (Lepidoptera: Pyralidae)
Common names: pyralid moth, pear gifted spot borer

10.11.1 Hazard identification

New Zealand status

Euzophera pyriella is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Over the last twenty years, *Euzophera pyriella* has become a major pest of pears in China (Lu, 2004). Infection levels in orchards of Korla, Xinjiang can reach 70–85% and fruit damage can reach 40% (Lu, 2004).

There are three generations of *E. pyriella* per year. It overwinters as mature larvae in the bark (Lu, 2004; Song et al, 1994); some overwintered larvae have been found in fruit (Lu, 2004). There are five larval instars, with the larvae from each generation lasting for 56, 46 and 240–270 (the overwintering generation) days, respectively (Song et al, 1994).

The larvae from the first generation feed mainly on stems and branches of pears; later generations feed on the fruit (Song et al, 1994), often in association with codling moth (Lu, 2004). One to five larvae are present in each fruit. The damage to the bark and trunk can promote secondary damage by wood-rotting fungi (Lu, 2004).

Overwintering occurs in the larval stage; pupation occurs in March of the following year and adults of the first generation emerge in late April, followed by peak emergence of the second and third generations in mid June and mid-late July, respectively. Adults mate two to five days post-emergence and the females lay eggs one to four days later. Females lay an average of 43 eggs on the bark of pear trees (Lu, 2004).

Ten- to fifteen-year-old pear trees are the preferred hosts, and older trees support larger populations (Lu, 2004).

Hosts

E. pyriella is monophagous.
Pyrus sp. nr *communis* (Lu, 2004; AQSIQ, 2007). Although *Pyrus bretschneideri* has also been recorded as a host (abstract in CAB abstracts, 2008), it is likely that this is a mistranslation of the common name in the abstract (Kuerle pear) (Song et al, 1994).

Plant parts affected

Fruit, branches and trunk of pear trees (Lu, 2004; Song et al, 1994).

Geographical distribution

Asia: China (Xinjiang) (Lu, 2004; Song et al, 1994)

Hazard identification conclusion

Euzophera pyriella is associated with the fruit of *Pyrus* sp. nr. *communis*. It is present in Xinjiang, China and is not known to be present in New Zealand. It is considered to be a potential hazard on the *Pyrus* fruit from China pathway.

10.11.2 Risk assessment

Entry assessment

The adults, pupae and eggs of *E. pyriella* are not associated with the fruit of pear. The larvae of *E. pyriella* are associated with the fruit of *Pyrus* sp. nr. *communis. E. pyriella* is recorded from Xinjiang only.

There is little information on the morphology of *E. pyriella*. It is assumed that the larvae are similar in size to others of the genus, such as *Euzophera ostricolorella*, the larvae of which are 23–33 mm in length when mature (ForestPests, 2008). If this is the case, damage to the fruit is likely to be noticed during harvest.

The larvae are internal in pear fruit. They are known to overwinter at the larval stage throughout the Xinjiang region and have been known to overwinter in fruit. It is assumed they will be able to survive transit to New Zealand.

Given that:

- eggs, pupae and adults are not likely to be associated with fruit;
- larvae feed inside fruit and may not be detected at harvest;
- larvae are likely to survive transfer to New Zealand;

The likelihood of entry is considered to be moderate (Pyrus sp. nr. *communis only) and therefore non-negligible.*

Exposure assessment

Imported fresh pear fruit (*P.* sp. nr. *communis*) are likely to be distributed throughout New Zealand's city centres and provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. In addition, whole fruit or parts of the fruit are not always consumed, especially if the fruit are infested or decaying. The waste material generated may allow some *E. pyriella* larvae to disperse from the discarded fruit, find a suitable host and pupate. No information is available on the distance that larvae of this species is able to crawl, but it is not likely exceed a few metres. Crawling larvae are likely to be vulnerable to predation. Since *E. pyriella* is monophagous a larva would have to find a pear tree. It is assumed that *Pyrus communis* would be a host for this species. *P. communis* grows in domestic and commercial situations throughout much of New Zealand.

Given that:

- larvae are mobile to a limited degree;
- *E. pyriella* is monophagous, but pears are widely distributed in New Zealand in both domestic and commercial situations

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

Since *E. pyriella* reproduces sexually, multiple larvae would need to enter and pupate in the same area, in order for an emerging adult to find an individual of the opposite sex to establish a viable population. This is a likely scenario as up to five larvae infest a single fruit.

E. pyriella is apparently restricted to the Xinjiang Autonomous Region. The climate in Xinjiang is dry with plenty of sunshine and little precipitation. Temperatures vary in the north and the south and between day and night. The hottest month in Xinjiang is July (average 25ºC) and the coldest month is January (-20ºC in the north and -10ºC in the south). This is attributed to the large land mass and varying topography, including the Tian Shan mountain ranges, deep basins, massive desert areas and the longest river in China (China Culture, 2003). The climate in New Zealand varies from sub-tropical in the north to temperate further south. The driest region in New Zealand is east of the Southern Alps (NIWA, 2007).

E. pyriella has apparently not expanded its distribution in China. It is possible that the difference between the more continental climate of its current range and that of New Zealand may present a barrier to establishment.

Given that:

- *E. pyriella* reproduces sexually, but multiple larvae can occur in one fruit;
- the host range is limited but hosts are widely distributed;
- climate may be a barrier to establishment;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

E. pyriella attacks the bark of its host plant and secondary damage can result from bacterial or fungal rot. High populations of the pest and rot-causing micro-organisms can severely damage or kill the host plant. *E. pyriella* also damages the fruit. Should it become established in New Zealand, it is likely to have an impact on European pear orchards, and back garden fruit production. Whilst the impact for individual pear growers might be high, the potential economic impact to New Zealand is considered to be low.
The potential economic impact within New Zealand is considered to be low, but non-negligible.

Environmental consequences

E. pyriella is monophagous on pears. There are no native *Pyrus* species in New Zealand.

Human health consequences

There are no known human health hazards caused by *E. pyriella*.

Risk estimation

Euzophera pyriella has a moderate likelihood of entry and a low likelihood of exposure and very low likelihood of establishment in New Zealand. The potential economic impact within New Zealand is low. *As a result the risk estimate for E. pyriella is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There is little information available on the biology of *E. pyriella* and since it is only known from Xinjiang province, the likelihood of it establishing in New Zealand is uncertain. It is assumed that *Pyrus communis* is a suitable host.

10.11.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest-free area

E. pyriella is only recorded from Xinjiang province. If its absence from the other pear producing provinces can be verified in accordance with ISPM No. 4 (see section 4.2) then pest-free area status may be a viable option for some pears.

Bagging of fruit

Individual bagging of fruit is likely to prevent *E. pyriella* from reaching the surface of the fruit. *Pyrus* sp. nr. *communis* fruit are not bagged (see section 4.4) and this is not a viable option for these pears.

Phytosanitary inspection prior to export

Larvae are internal and there can be up to five individuals per fruit. It is assumed that entry holes and damage are likely to be visible during visual inspection, but the efficacy of this measure is unknown.

Cold treatment

This moth is highly tolerant of cold climates, and has been known to overwinter in fruit. Cold treatment is unlikely to be effective.

Ethyl formate fumigation

Ethyl formate is a naturally occurring component in fruit with insecticidal properties that has been used as a fumigant for stored products. Pupae of the tortricid moth, *Platynota stultana* had an LD_{99} of 4% at two hours treatment. Bartlett pears tested for one hour at room temperature had a maximum tolerance dose of 3.2%. Doses in excess of this caused skin browning (Mitcham, 2005). The effective dose for treatment against *E. pyriella* larvae is not known, but it is an option that warrants further investigation.

A combination of fruit bagging and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

10.12 *Hyphantria cunea – fall webworm*

Scientific name: *Hyphantria cunea* Drury, 1770 (Lepidoptera: Arctiidae)
Other relevant scientific names: *Hyphantria textor* (Harris)
Common names: mulberry moth, blackheaded webworm, redheaded webworm, fall webworm, American white moth

10.12.1 Hazard identification

New Zealand status

Hyphantria cunea is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001). It has been recorded in New Zealand five times over the period, 2003–2005 (PPIN, 2008). In 2006, MAF declared *H. cunea* to be eradicated from New Zealand.

Biology

Hyphantria cunea has caused significant damage to forests and ornamental trees in China since it was first found in Liaoning in 1979 (Yang and Zhang, 2007; Ji et al, 2003).

H. cunea is native to North America. In New York, USA, there is one generation of *H. cunea* per year. In other parts of the USA there can be more. Adults emerge in late spring to early summer. Oviposition occurs on the underside of leaves and larvae emerge 10–14 days later. As the larvae feed, they spin silken webs from which they construct protective nests. The nests become noticeable when larvae have been feeding for three to four weeks. When the larvae reach full size they actively seek suitable pupations sites in protected areas including soil, leaf litter, bark crevices and inanimate objects. Depending on the conditions during larval development the pupae will either be diapausing or non-diapausing (MAF Biosecurity New Zealand, 2008).

In Japan, the first record of *H. cunea* was in 1945, when larvae were collected from a ‘nest web’ on poplars (Umeya and Ito, 1977). For 30 years, there were two generations of *H. cunea* per year throughout Japan; this has increased to three generations in south-western parts of Japan. This has been attributed to a shorter diapause period (Gomi, 2007). In addition, the duration of the larval stage in the south-west areas are shorter, compared with other areas (Gomi et al, 2003; Gomi, 2007).

In the Krasnodar region of Russia, there are two generations of *H. cunea* a year. Adults emerge in April-early May and fly for seven to ten days at temperatures above 15ºC. Activity peaks in warm conditions, with temperatures between 20 and 28ºC. Flight occurs in the evening and moths can fly several kilometres, but most flights are less than 300 m (MAF Biosecurity New Zealand, 2008). Females lay between 300 and nearly 2000 eggs. Adults prefer humid conditions; conditions are most favourable at 70–80% RH and temperatures between 22 and 25ºC (EPPO, 1979).

Hosts

H. cunea has a very large host range encompassing hundreds of species in a wide range of families (MAF Biosecurity New Zealand, 2008) including a number of horticultural crops and amenity species. *Pyrus pyrifolia* (Warren and Tadic, 1970) *Pyrus communis* (Babil and Starets, 1971) are recorded hosts.

Plant parts affected

H. cunea larvae feed mainly on the leaves of host plants. However, Brunner and Zack (1993) state that if fruit is enclosed in the webs they will feed on it. This is the only mention of an association with fruit. *H. cunea* is known to be a hitchhiker species, principally in the pupal stage (MAF Biosecurity New Zealand, 2008). However there is no evidence of this sort of association with this commodity.

Geographical distribution

H. cunea is native to North America, and has been introduced into Europe and East Asia (CPC, 2007).

In China it is recorded from Beijing (Yang and Zhang, 2007); Liaoning, Hebei, Shandong and Tianjin (Ji et al, 2003).

Hazard identification conclusion

Hyphantria cunea has been recorded on *Pyrus*. It is present in China and is not known to be present in New Zealand. It is not normally associated with fruit, and larvae would only be present if the fruit were encased in a web. Such fruit would not be harvested. It is not considered to be a potential hazard.

Note that although *Hyphantria cunea* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a ‘regulated pest’. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

10.13 *Leucoptera malifoliella* – pear leaf miner

Scientific name:	*Leucoptera malifoliella* Costa, 1836 (Lepidoptera: Lyonetiidae)
Other relevant scientific names:	*Cemiostoma scitella* Zeller, 1848; *Elachista malifoliella* Costa; *Leucoptera scitella* Zeller, 1839; *Opostega scitella* Zeller, 1839
Common names:	pear leaf miner, pear leaf blister moth, apple leaf miner, ribbed apple leaf miner

10.13.1 Hazard identification

New Zealand status

Leucoptera malifoliella is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

High populations of *Leucoptera malifoliella* lead to heavy loss of leaves and smaller fruit, and hence reduced fruit quality and yield (CPC, 2007). In France it is of minor economic importance, but its presence on fruit for export can be a problem (Boureau, 1982).

There are between one and four generations of *L. malifoliella* a year; larger numbers of individuals occurring in later generations and in warmer conditions (Boureau, 1982). For example, in France, larvae from the first, second, third and fourth generations are present from early May, early July, mid-August and early October. However, those of the last generation are unable to complete their development before winter (Blanc, 1983).

Newly-hatched larvae feed on leaves and create mines in the leaf tissue once fully mature (Blanc, 1983; CPC, 2007; Maciesiak, 1999; Mey, 1988). Fully-grown larvae emerge from the mines through the upper surface of the leaf and begin to search for pupation sites. They often climb down on silk fibre. The caterpillars spin white cocoons 6–7 mm long and 3–4 mm wide (Boureau, 1982) in which they pupate. The larvae of the first generation pupate mainly on leaves, whereas the later generations pupate in bark crevices or on the fruit. The pupae are often found in groups and are strongly attached (Boureau, 1982). *L. malifoliella* overwinters as a diapausing pupa. Cocoons have been found at the stem and calyx ends of imported apples and pears (CPC, 2007). In France, pupal mortality over winter reaches 80%, and 50% in summer (Boureau, 1982).

In Southern Europe, adults emerge between the end of March to mid-April, when temperatures average 12°C and the second and third generations appear in mid-June and mid-July, respectively. Adults normally live for four to seven days. Fifty to 100 eggs are deposited singly on the undersides of leaves (Boureau, 1982).

To be effective, insecticides need to be applied against eggs or young larvae (Boureau, 1982).

Hosts

Rosaceae: many hosts (CPC, 2007).

Major hosts: *Cydonia oblonga*, *Malus domestica*, *Prunus avium*, *Pyrus* sp. (CPC, 2007); *Pyrus communis* (CPC, 2007; Matis, 2004).

Minor hosts: *Betula* sp., *Chaenomeles* sp., *Cotoneaster* sp., *Crataegus* sp., *Malus sylvestris*, *Mespilus germanica*, *Pistacia vera*, *Prunus armeniaca*, *Prunus cerasus*, *Prunus domestica*, *Prunus persica*, *Prunus salicina*, *Prunus spinosa* (CPC, 2007); *Pyrus bretschneideri* (CPC, 2007; AQSIQ, 2007); *Pyrus pyrifolia* (AQSIQ, 2007); *Pyrus* sp. nr. *communis*, *Rhamnus frangula*, *Sorbus aucuparia* (CPC, 2007).

Although *Pyrus* is described as a minor host by CPC, *L. scitella* is described as a serious pest of apple, pear, quince and cherry in Yugoslavia (Zivanovic, 1967) and AQSIQ (2007) indicates that it occurs frequently on *P.* sp. nr. *communis and P. bretschneideri.*

Plant parts affected

Leaf mines, cocoons on fruit (Boureau, 1982).

Geographical distribution

Asia: China (Garland, 1995; CPC, 2007; Woo, 1961); Iran, Kazakhstan, Turkey, Turkmenistan, Uzbekistan (CPC, 2007).
Europe: Albania, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France (CPC, 2007); Germany (Mey, 1988); Hungary, Ireland, Italy, Netherlands, Norway (CPC, 2007), Poland (Maciesiak, 1999); Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom (England, Wales, Scotland), Yugoslavia (Zhang, 1994).

Within China, *L. malifoliella* is recorded in Shandong, Henan and Shaanxi (Woo, 1961).

Hazard identification conclusion

Leucoptera malifoliella has been recorded on *Pyrus bretschneideri*, *P. pyrifolia* and *Pyrus* sp. nr. *communis*, and pupae have been reported associated with the fruit. It is present in China. It is not known to be present in New Zealand and is considered to be a potential hazard.

10.13.2 Risk assessment

Entry assessment

The only lifestage likely to be associated with mature fruit is the pupa. The frequency of pupation on fruit is not known and will depend on the timing of harvest in relation to the development of the insect on the host tree. Later generations of larvae are apparently more likely to pupate in bark crevices or on the fruit than early generations. Pupae of *L. malifoliella* have reportedly been intercepted at the Canadian border on apple fruit (CPC, 2007). The cocoons are white and spindle-shaped, about 3–4mm long. As the pupae are tiny and when associated with fruit are often situated within the calyx, they may be difficult to detect.

The development of *L. malifoliella* pupae has a lower threshold of 7.5ºC (Andreev and Kutinkova, 2002). Since *L. malifoliella* diapauses at the pupal stage, it is assumed it would survive shipment from China to New Zealand. However pupal mortality in France is reported to be between 50 and 80%.

Given that;

- pupae can be associated with mature pear fruit;
- the pupae are small and may be difficult to detect during harvest and packing;
- the pupa is the over-wintering life stage but mortality is high;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed in large quantities throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and often the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit can be discarded.

Adults are mobile; should pupae-infested fruit be disposed of near a Rosaceae host plant, such as *Pyrus, Malus, Crataegus, Prunus* or *Cydonia oblonga*, the likelihood of emerging adults finding a host would be high. These genera are widely distributed in New Zealand. The infested fruit would need to be discarded in appropriate conditions for the pupa to continue its development.

Given that:

- infested fruit would need to be discarded in appropriate conditions for the pupa to complete its development;
- adults emerging from pupae are mobile;
- host plants are widely distributed in New Zealand in both domestic and commercial situations;

The likelihood of exposure is considered to be low and therefore non-negligible.

Establishment assessment

To establish in New Zealand, male and female individuals would need to be introduced at the same time and into the same area. The likelihood of this would be increased if multiple pupae arrive on a single fruit.

Rosaceae host plants of *L. malifoliella* grow wild, are widely cultivated in New Zealand. They are mainly deciduous, but fruit from China would be expected to arrive in New Zealand in spring, when new leaves are available. The lower temperature thresholds for *L. malifoliella* eggs, larvae and pupae development are 6.5, 1.5 and 7.5ºC, respectively (Andreev and Kutinkova, 2002), thus there is potential for multiple generations a year, which would enable populations to build up quite rapidly. *L. malifoliella* has established successfully in several countries in continental Europe that have cool-temperate climates and it is assumed that New Zealand's climate would not be a barrier to its establishment.

Given that:

- *L. malifoliella* reproduce sexually, but pupae may have a clumped distribution;
- suitable hosts are widely distributed in New Zealand; and
- climate is unlikely to be a barrier;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

Larvae of *L. malifoliella* can cause damage to several species of fruit trees that are grown commercially in New Zealand. Larvae feed on leaves of hosts, creating mines in them. Heavy leaf loss from larval feeding results in small sometimes unmarketable fruit, reducing quality and yield.

L. malifoliella prefers Rosaceae hosts, particularly apples and pear. New Zealand has a large pipfruit industry and infestation by *L. malifoliella* could lead to losses in the industry. Furthermore, since *L. malifoliella* is currently only located in Europe and Asia, if the pest was to establish in New Zealand, there may be an impact on market access for New Zealand pomes and stonefruit and other Rosaceae to the USA or Australia.
The potential economic impact within New Zealand is considered to be moderate.

Environmental consequences

Host plants of *L. malifoliella* are widely distributed throughout New Zealand. Although there are native Rosaceae (*Acaena*, *Geum*, *Potentilla* and *Rubus*), none of the known host plant genera have New Zealand native members.
The potential environmental impact within New Zealand is uncertain but likely to be low.

Human health consequences

There are no known human health impacts.

Risk estimation

Leucoptera malifoliella has a low likelihood of entry, exposure and establishment in New Zealand. The potential economic impact within New Zealand is moderate, therefore non-negligible. *As a result the risk estimate for L. malifoliella is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

The frequency with which the pupae of *L. malifoliella* are associated with pear fruit at the time of harvest is unknown.

10.13.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

L. malifoliella is recorded from Shandong, Henan and Shaanxi and may be an option if its distribution can be confirmed. The main growing area for export for *Pyrus* sp. nr. *communis* is Xinjiang; pest free area status may be an option for these fruit if this distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

Bagging of fruit

The practice of individual bagging of the fruit is likely to prevent larvae from pupating around the calyx, although the efficacy of this measure has not been quantified.

High pressure air brushing

Whilst the efficacy of this measure has not been quantified, it may be expected to remove some pupae from the surface of the fruit, but they are reported to be strongly attached.

Phytosanitary inspection prior to export

Only the pupae are associated with fruit. The cocoons are described as tiny and white. Some may not be detected if present at low frequencies, but clumped distribution would increase the likelihood of detection.

Cold treatment

Since *L. malifoliella* overwinters at the pupal stage and pupae are the transported life stage, cold treatment is unlikely to be a viable option.

A combination of fruit bagging, airbrushing and phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

10.14 *Lymantria dispar – gypsy moth*

Scientific name: *Lymantria dispar* Linnaeus, 1758 (Lepidoptera: Tortricidae)

Other relevant scientific names: *Bombyx dispar* Linnaeus; *Hypogymna dispar* Linnaeus; *Liparis dispar* Linnaeus; *Ocneria dispar* Linnaeus; *Phalaena dispar* Linnaeus; *Porthesia dispar* Linnaeus; *Porthetria dispar* Linnaeus

Common name: gypsy moth

10.14.1 Hazard identification

New Zealand status

Lymantria dispar is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001). There is one record of a male gypsy moth in Hamilton, New Zealand, in March 2003 (PPIN, 2008). *L. dispar* has since been eradicated (Armstrong et al, 2003).

Biology

Lymantria dispar is a very destructive defoliating species, mainly attacking new growth. It has one generation per year. The eggs overwinter, and hatch when new leaves are produced by the host tree. Newly-hatched larvae may remain on the egg masses for several days before moving to the branch tips of trees, where they feed on buds and new leaves. Feeding generally occurs during the day, however, final-instar larvae mostly feed at night. The principal means for dispersal of first instar larvae is by wind; as larvae move up a host tree, they spin a thread of silk and suspend themselves from the threads. These threads eventually fracture and the larvae are carried by the wind. While most do not move more than 200 m, some have been known to travel several kilometres (CPC, 2007).

The larval stage lasts six to eight weeks, after which they pupate within a silken nest. Pupal development is complete within two to three weeks. Males emerge one or two days before females; at emergence both sexes are sexually mature. Males are more active and fly well, but females are less active and, in some areas remain flightless, although their wings are fully formed. In Asia, however, females are capable of flight (CPC, 2007).

After emergence, females release a pheromone to attract males. Mating lasts for up to one hour and immediately after mating oviposition begins. Each female lays a single egg mass of 80–1200 eggs. Eggs are laid on a wide range of permanent structures including tree trunks, walls, ships, cars etc, but are not considered to be associated with foliage and fruit (MAF Biosecurity New Zealand, 2008). Eggs undergo obligatory diapause (CPC, 2007).

Hosts

L. dispar is highly polyphagous, and the host list for the Asian biotype contains more than 300 genera and 100 families (Savotikov et al, 1995). In general, deciduous species are preferred to evergreens (MAF Biosecurity, 2008).
Pyrus pyrifolia, *P. bretschneideri* (AQSIQ, 2007) and *P. communis* (Liebhold et al, 1995) are recorded as hosts.

Plant parts affected

Although *L. dispar* is mainly associated with leaves, and to some extent twigs and flowers, Liotta (1970) stated that it also attacked unripe pear fruit in Sicily. At the time that mature fruit are present, *L. dispar* is likely to be present as either adults or more likely egg masses, as larval hatching occurs when new leaves are present in spring.

Geographical distribution

L. dispar is native to Eurasia, its range extending to North Africa and Japan. It has been introduced to North America and has established over large areas there (CPC, 2007).

Within China, *L. dispar* is recorded in Hebei, Heilongjiang, Jiangsu, Jiangxi, Jilin, Liaoning, Shandong, Taiwan and Xizang (CPC, 2007).

Hazard identification conclusion

Lymantria dispar has been recorded on *Pyrus*. It is present in China and it is not known to be present in New Zealand. Although it is primarily a defoliator, there is a single record of *L. dispar* being recorded on *Pyrus* fruit. However, the fruit in this case was unripe (Liotta, 1970). This was the only record of it on fruit of any host species, and at the time pear fruits are being harvested it is likely to be present as egg masses, which are not reported on fruit. It is not likely to be associated with the commodity and is not considered a potential hazard.

Note that although *Lymantria dispar* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

10.15 *Malacosoma neustria – common lackey moth*

Scientific name:	*Malacosoma neustria* (Linnaeus, 1758) (Lepidoptera: Lasiocampidae)
Other relevant scientific names:	*Bombyx neustria* Linnaeus, 1758; *Clisiocampa neustria* (Linnaeus, 1758); *Gastropacha neustria* (Linnaeus, 1758); *Lasiocampa neustria* (Linnaeus, 1758); *Malacosoma flavescens* Grünberg, 1912; *Malacosoma mauginii* Turati, 1924; *Malacosoma neustrium* (Linnaeus, 1758); *Phalaena neustria* Linnaeus, 1758; *Trichoclia neustria* (Linnaeus, 1758)
Common names:	common lackey moth, common province rose lackey, European lackey moth, Motschulsky tent caterpillar, lackey caterpillar, tent caterpillar

10.15.1 Hazard identification

New Zealand status

Malacosoma neustria is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

In Eastern Europe, *Malacosoma neustria* is prone to population explosions and larvae have been known to defoliate entire orchards (CPC, 2007). Gorbunov (1991) reports that larvae feed on new growth, including the leaves, stems and buds of fruit trees, but not fruit. However, Rilishkene and Zayanchkauskas (1980) report damage to between 4% and 100% of fruit in some apple orchards in Lithuania. Young larvae spin large silken-web tents where they group together. In the final instar, larvae disperse and become solitary. The larvae feed from April/May until June, and then pupate in individual silken cocoons amongst foliage (CPC, 2007).

The non-feeding, diurnal/nocturnal males and strictly nocturnal females fly from late June until early September. Females lay their eggs in ring clusters of 200–300 around a twig, where they remain throughout the winter and hatch in April-May of the following year (CPC, 2007).

Hosts

M. neustria is polyphagous on trees and shrubs. Recorded hosts include:
Betula sp., *Corylus avellana, Crataegus monogyna, Fagus sylvatica, Larix kaempferi, Malus domestica*, *Populus nigra*, *Prunus avium, Prunus domestica*, *Prunus dulcis*, *Prunus salicina*, *Prunus spinosa,* (CPC, 2007); *Pyrus communis* (CPC, 2007; Coruh and Ozbek, 2002; Sedivy, 1978; Shiga, 1976); *P. pyrifolia* and *P. bretschneideri* (AQSIQ, 2007), *Quercus ilex, Q. petraea, Q. robur, Q. suber, Rosa canina, Rubus fruticosus, Salix caprea, Tilia* sp.*, Ulmus* sp. (CPC, 2007).

Plant parts affected

Eggs are laid on twigs; larvae feed on leaves (CPC, 2007). Rilishkene and Zayanchkauskas (1980) reports damage to between 4% and 100% of fruit in some apple orchards in Lithuania.

Geographical distribution

Asia: Armenia, China, Georgia, Japan; Korea, Syria (CPC, 2007); Turkey (Coruh and Ozbek, 2002).
Europe: Albania, Austria, Belgium, Bulgaria (CPC, 2007); Czechoslovakia (Sedivy, 1978); Denmark, Estonia, Finland, France, Corsica, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Ukraine (CPC, 2007); United Kingdom (Pearce, 1988).

Within China, *M. neustria* is recorded in Jilin and Liaoning (CPC, 2007).

Hazard identification conclusion

Malacosoma neustria has been recorded on *Pyrus communis* and has been recorded on the fruit of host plants. It is present in China and is not known to be present in New Zealand. It is considered to be a potential hazard.

10.15.2 Risk assessment

Entry assessment

M. neustria is a defoliator of trees and shrubs. Only one reference was found (Rilishkene and Zayanchkauskas, 1980) for damage to fruit, relating to apples in Lithuania. However, even if larvae are associated with pear fruit in China, the larval period ends well before harvest time. The life stages expected to be present at harvest are adults and eggs. Adults are mobile and would not remain on the fruit during the harvest and packing processes and eggs are laid on twigs, not fruit. Therefore no lifestage is likely to be associated with mature pear fruit at harvest.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Malacosoma neustria* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for M. neustria is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *M. nuestria* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

10.16 *Oraesia spp. and Calyptra lata – fruit piercing moths*

Scientific name: *Oraesia emarginata* Fabricius (Lepidoptera: Noctuidae)
Other relevant scientific names: *Calpe emarginata* Fabricius; *Calyptra emarginata* Fabricius; *Noctua emarginata* Fabricius
Common names: fruit-piercing moth, small oraesia

Scientific name: *Oraesia excavata* Butler (Lepidoptera: Noctuidae)
Other relevant scientific names: *Calpe excavata* Butler; *Calyptra excavata* Butler
Common names: fruit-piercing moth, reddish oraesia

Scientific name: *Calyptra lata* Butler (Lepidoptera: Noctuidae)
Other relevant scientific names: Was *Oraesia lata* Butler
Common names: fruit-piercing moth

10.16.1 Hazard identification

Taxonomy

Calyptra lata was previously known as *Oraesia lata*, and has been examined with the two above species of *Oraesia*. The current name is *Calyptra lata* (Zaspel and Branham, 2008).

New Zealand status

Oraesia emarginata, Oraesia excavata and *Calyptra lata* are not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Adults of both *Oraesia emarginata* and *O. excavata* damage the fruit of their respective host plants (Yoon and Lee, 1974; Younghusband, 1980; Zhang, 1994; CPC, 2007; Liu, 2002; Liu and Kuang, 2001). *O. excavata* moths attacked 3.4% pear fruit in Jinju, Korea, during the summer and autumn seasons (Lee et al, 1970).

In the fruit orchards of Hubei, China, *O. emarginata* and *O. excavata* are the dominant species of fruit-piercing moths (Liu, 2002; Liu and Kuang, 2001). Both species cause damage on peach, loquat and citrus, and overwinter as larvae in clusters of weeds and soil cracks around the host plant. Larval populations of *O. emarginata* peak in September and October, and *O. excavata* larval populations peak in June, August and October (Liu and Kuang, 2001).

In Japan, the adults of both species emerge from pupae and begin to oviposit in early June, four to nine days post-emergence. The adults are nocturnal (Yoon and Lee, 1974). The larvae hatch from eggs between early June to mid-August and the life cycle is completed within the same year (Ogihara et al, 1992). The total number of eggs laid by female *O. emarginata* was normally between 1023 and 1224 and the maximum was 1830 (Ogihara et al, 1996).

In Zimbabwe, larvae do not feed on fruit, but on plants from the Menispermaceae family (Younghusband, 1980). Fruit is attacked by the adult stage only. The adults are associated directly with the fruit and fruit clusters, but only at night (Hanken, 2000 (revised 2002)).

Little information is available on *Calyptra lata*. AQSIQ (2009) reports that as for the other two species, the adults feed on the fruit and the puncture wounds cause the fruit to deteriorate and sometimes fall off the tree.

Hosts

- *Oraesia emarginata*: *Cocculus trilobus* – larval host (Liu and Kuang, 2001; Zhang, 1994); *Citrus* spp. (CPC, 2007; Liu, 2002; Liu and Kuang, 2001); *Pyrus* sp. (Biosecurity Australia, 2005); *Prunus persica*, *Eriobotrya japonica*, *Citrus* sp. (Liu and Kuang, 2001).

- *Oraesia excavata*: *Malus domestica* (Liu, 2002); *Prunus persica, Prunus dulcis* (Liu, 2002); *Pyrus* sp. (CPC, 2007; Liu, 2002; Liu and Kuang, 2001); *Vitis* spp. (Zhang, 1994); *Prunus persica*, *Eriobotrya japonica*, *Citrus* sp. (Liu and Kuang, 2001).

- *Calyptra lata:* Orange is the main host but the fruit of apple, plum, pear, peach, apricot and grape are also damaged (AQSIQ, 2009).

Plant part affected

Adults are associated with fruit (Yoon and Lee, 1974).

Geographical distribution

Both *O. emarginata* and *O. excavata* have similar distributions:
Asia: China (Hubei) (CPC, 2007; Liu, 2002; Liu and Kuang, 2001); India (CPC, 2007); Korea (Kim and Lee, 1986; Park et al, 1988); Japan (Ogihara et al, 1992); Thailand (Zhang, 1994).
Oceania: Vanuatu (*O. emarginata* only) (Muniappan et al, 2002).

Calyptra lata reportedly occurs in some regions of China (AQSIQ, 2009).

Hazard identification conclusion

Oraesia excavata, *O. emarginata* and *Calyptra lata* have been recorded on *Pyrus*, and are associated with the fruit and flowers of host plants. They are present in China. They are not known to be present in New Zealand, and are considered to be a potential hazard.

10.16.2 Risk assessment

Entry assessment

Only the adults of these species are associated with fruit. The adults are nocturnal and pear fruit are harvested during the day. The moths are relatively large (*O. emarginata*: 16–19 mm, *O. excavata*: 23–26 mm, *O. lata*: 25 mm) and are highly mobile (Liu, 2002; USDA, 2006).

Given that:

- only the adults are associated with the fruit;

- the adults are nocturnal and therefore unlikely to be associated with fruit while it is being harvested;
- the adults are highly mobile and are likely to be disturbed and fly away if present on fruit at harvest;
- the adults are large (around 15–25 mm) and therefore readily visible;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Oraesia excavata*, *O. emarginata* and *Calyptra lata* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for these organisms is negligible and they are not classified as hazards in the commodity. Therefore risk management measures are not justified.*

Assessment of uncertainty

There is little available information on *Oraesia excavata* and *Calyptra lata*. It is assumed that their biology is similar to that of *O. emarginata.*

10.17 *Orgyia postica – cocoa tussock moth*

Scientific name:	*Orgyia postica* (Walker, 1855) (Lepidoptera: Lymantriidae)
Other relevant scientific names:	*Lacida postica* (Walker, 1855); *Notolophus australis posticus* (Walker, 1855); *Notolophus postica* (Walker, 1855); *Notolophus posticus* (Walker, 1855); *Orgyia australis postica* (Walker, 1855); *Orgyia ceylanica* Niet., 1862; *Orgyia ocularis* Moore; *Orgyia posticus* (Walker, 1855)
Common names:	cocoa/cacao tussock moth, small tussock moth, small tussock caterpillar

10.17.1 Hazard identification

New Zealand status

Orgyia postica is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Complete defoliation of the host plant by *Orgyia postica* has been observed which has led to tree stunting or death (Fasih et al, 1989; Sanchez and Laigo, 1968). The larvae take 15–28 days to complete five instars. The larvae feed on the leaves, preferably the tender ones, until only the veins are left (de Alwis, 1926). The later stages feed on leaves and nibble new soft shoots. In cases of severe attack on mangoes in India, fruit stalks and fruits were also scraped, resulting in drying up of affected tissues and rendering the fruit unmarketable (Fasih et al, 1989). Pupation occurs in a cocoon spun between leaves or on twigs (de Alwis, 1926; Sanchez and Laigo, 1968).

Female moths are wingless, and cling to the cocoon from which they emerged. Oviposition generally occurs on the cocoon and females lay an average of 230 eggs. Larvae hatch 5–6 days later (Sanchez and Laigo, 1968).

Hosts

Amherstia nobilis, *Camellia sinensis* sp., *Cinchona* sp., *Cinnamomum* sp., *Coffea* sp., *Durio zibethinus* (Zhang, 1994); *Eugenia jambolana* (Fasih et al, 1989); *Erythrina* spp., *Euphorbia longana*, *Garcinia mangostana*, *Glycine max*, *Hevea brasiliensis*, *Lablab purpureus*, *Leucaena leucocephala*, *Litchi chinensis*, *Malpighia glabra*, *Nephelium lappaceum*, Orchidaceae (Zhang, 1994); *Mangifera indica* (Fasih et al, 1989); *Pinus* (Fasih et al, 1989); *Populus deltoides*, *Pyrus communis* (CPC, 2007) Pear (Fasih et al, 1989); *Ricinus communis*, *Rosa* sp., *Syzygium cumini*, *Theobroma cacao*, *Vigna radiata*, *Ziziphus jujube* (CPC, 2007; Zhang, 1994); *Vitis* sp. (Chang, 1988).

Plant parts affected

Larvae feed on leaves and pupate on leaves and stems (Sanchez and Laigo, 1968); fruit of mango (Fasih et al, 1989; Gupta and Singh, 1986).

Geographical distribution

Asia: Bangladesh, China (Fujian, Guangdong, Guangxi, Hainan, Yunnan) (CPC, 2007; Zhang, 1994); India, Indonesia, Japan, Malaysia, Philippines, Sri Lanka, Taiwan (Zhang, 1994).

Hazard identification conclusion

Orgyia postica is a pest of pears and has been reported on fruit of mangoes. It is present in China and not known to be present in New Zealand and is considered a potential hazard.

10.17.2 Risk assessment

Entry assessment

Orgyia postica is known as a defoliator, but there are reports of larvae feeding on the fruit of mango in India (Fasih et al, 1989; Gupta and Singh, 1986). This appears to occur rarely and results in scarring of the fruit, which is likely to be detected at harvest. No reference has been found of larvae feeding on the fruit of pears. *O. postica* is present in southern China, but not in the main pear growing regions. It is therefore unlikely to be prevalent in pear orchards.

Given that:

- it is not known whether larvae feed on fruit of pears;
- any infestation of fruit is likely to be readily detectable;
- *O. postica* is not recorded from the main pear growing areas of China;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Orgyia postica* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for O. postica is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *Orgyia postica* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

There is relatively little information on the biology of *O. postica* on *Pyrus* hosts. Information relating to mangoes may not be relevant.

10.18 *Pandemis spp. – fruit tree tortrix*

Scientific name: *Pandemis cerasana* (Hübner) (Lepidoptera: Tortricidae)
Other relevant scientific names: *Pandemis ribeana* Hübner; *Pandemis flavana* Stephens; *Pandemis grossulariana* Stephens
Common names: common twist moth, currant tortrix, barred fruit-tree tortrix

Scientific name: *Pandemis heparana* (Denis and Schiffermüller, 1775) (Lepidoptera: Tortricidae)
Other relevant scientific names: *Argyroploce heparana* (Denis and Schiffermüller); *Tortrix heparana* Denis and Schiffermüller
Common names: apple brown tortrix, dark fruit tree tortrix, brown tortrix moth

10.18.1 Hazard identification

New Zealand status

Pandemis cerasana and *P. heparana* are not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

These species are part of a group of leaf rolling tortricids that also includes *Adoxophyes orana*. *P. heparana* is reportedly a more important pest than *P. cerasana* in Europe (Dickler, 1991).

Pandemis cerasana
P. cerasana has two generations a year. Larvae overwinter in a silken shelter under a dry leaf fixed by a silken thread to the branches. From bud-swelling onwards, the larvae feed on shoots, inflorescences and recently-formed fruit or the points of contact of fruit with leaves or twigs (CPC, 2007).

The first generation adults appear from mid-May to early June. The larvae of the first generation hatch in the first half of June, after 7–10 days of incubation. The final-instar larvae pupate and adults emerge 8–10 days later. The second generation adults fly from mid-July to August. The larvae of the second generation hatch after 8–10 days, and over-winter in diapause (CPC, 2007).

Larvae damage leaves, flowers and young fruit of pears and apples, which may result in blemished fruit at harvest (Castellari, 1988; CPC, 2007; Meijerman and Ulenberg, 2008; Pasqualini et al, 1992).

Pandemis heparana
P. heparana has two generations, but the second is partial in more temperate regions (Castellari, 1990). Larvae survive for an average of 39 days (Angelova, 1983). Larvae over-winter in the first- to fourth-instars and resume activity in early spring, during bud swelling (Angelova, 1983; Castellari, 1990). In apples, pupation of *P. heparana* takes place weeks after flowering (CPC, 2007).

In Italy, on apples and peaches, two generations of adults emerge in mid-May and in mid-August, respectively (Castellari, 1990; Scaramozzino and Ugolino, 1979). Adults become active at dusk. Females lay eggs a few days post-emergence on the upper surface of leaves, in 2 to 7 clusters, each containing 100–600 (Castellari, 1990). Eggs hatch in two to three weeks. The larvae spin webs around several leaves on which they feed; these webs sometimes include fruit.

In Europe, first generation larvae feed on buds, leaves, flowers and fruitlets, and the larvae of the next generation feed on leaves and mature fruit (Dickler, 1991; Scaramozzino and Ugolino, 1979). The damage to fruit is very similar to that of *A. orana* – stings and patch grazing (Dickler, 1991). Abrasions may develop into larger, russetted areas on mature fruit, rendering the fruit unmarketable (Scaramozzino and Ugolino, 1979).

In Bulgaria, larvae of the first generation last from mid-July to late August. Adults fly from mid-May to early July. Oviposition occurs only at temperatures of 15ºC or higher, with females laying an average of 62 eggs (Angelova, 1983).

Hosts

Pandemis cerasana
Apples and pear are the principal hosts. *Abies, Alnus, Acer, Betula, Crataegus, Corylus, Fraxinus* (Meijerman and Ulenberg, 2000); *Malus* (CPC, 2007); *Picea, Prunus avium, Prunus dulcis, Prunus persica*, *Pyrus* (CPC, 2007; Meijermann and Ulenberg, 2008; Zhang, 1994); *Pyrus communis* (CPC, 2007; Civolani and Pasqualini, 2000); pear (Dickler, 1991); *Quercus rhamnus* (Meijerman and Ulenberg, 2000; Zhang, 1994); *Ribes*, *Rosa, Rubus*, (CPC, 2007; Meijermann and Ulenberg, 2008); *Salix*, *Sorbus, Tilia*, *Ulmus, Vaccinium* (Meijerman and Ulenberg, 2000).

Pandemis heparana
Acer, *Alnus, Arcticum, Artemisia, Betula, Carpinus, Castanea*, *Cornus, Corylus, Cydonia, Erigeron, Fragaria*, *Juglans*, *Linum*, *Lonicera; Malus domestica*, *Morus, Myrica, Phaseolus*, *Phellodendron, Populus* (Meijerman and Ulenberg, 2000); *Prunus persica* (Scaramozzino and Ugolino, 1979); *Prunus, Pyrus communis* (CPC, 2007; Meijerman and Ulenberg, 2000); pear (Dickler, 1991); *Quercus*, *Ribes, Rosa*; *Rubus*; *Rumex, Salix, Sorbus, Tilia*, *Trifolium* and *Vaccinium* (Meijerman and Ulenberg, 2000).

Plant parts affected
Leaves; fruit (CPC, 2007; Dickler, 1991).

Geographical distribution

Pandemis cerasana
Asia: China (Zhang, 1994); India, Japan (Zhang, 1994); Turkey (Guclu and Ozbek, 2007).
Europe: Croatia, Czech Republic, Germany, Hungary, Italy (Castellari, 1988; Pasqualini et al, 1992); Lithuania, Poland, Russia, Siberia, Switzerland (Billen, 1988); United Kingdom (Cross, 1996).
North America: Canada (Loan and Doganlar, 1980; Zhang, 1994).

Pandemis heparana
Asia: China, Japan (Meijerman and Ulenberg, 2000; Zhang, 1994).

Europe: Belgium, Bulgaria (Angelova, 1983); France, Germany, Hungary, Italy (Castellari, 1990; Scaramozzino and Ugolino, 1979); Netherlands, Poland, Romania, Russia, Sweden, Switzerland, Ukraine, UK, Yugoslavia (CPC, 2007; Zhang, 1994).
North America: Canada (Mutuura, 1980).

Hazard identification conclusion

Pandemis cerasana and *P. heparana* have been recorded on *Pyrus*, and are associated with the fruit and flowers of host plants. They are present in China. They are not known to be present in New Zealand, and are considered to be potential hazards.

10.18.2 Risk assessment

Entry Assessment

The eggs, pupae and adults of *Pandemis cerasana* and *P. heparana* are not associated with the fruit of host plants.

Larvae of *P. cerasana* feed on leaves and young fruit and are not likely to be present at harvest. Second generation larvae of *P. heparana* are external and internal feeders; therefore it is possible that larvae would be transported either on or inside fruit. Multiple holes made by larvae and patch grazing wounds are likely to be visible and obviously damaged fruit is unlikely to be picked or packed.

P. heparana overwinters as third larval instars, which would be expected to survive transit to New Zealand.

Given that:

- larvae of *P. heparana* are likely to be present in fruit at harvest time;
- some infested fruit are likely to be detected and discarded during the harvest and packing process;
- the larvae present in harvested fruit are able to hibernate;

The likelihood of entry of P. heparana is considered to be low and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed in large amounts throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. Infested fruit are more likely to be thrown away. The waste material generated could allow some *P. heparana* larvae to disperse and find a suitable host. Larvae are capable of limited movement but there are no quantitative records of distances achieved. Adult moths are also mobile.

Many plants grown in New Zealand for horticultural purposes are host plants including fruit trees, poplars, willows and roses, and there would be no shortage of host material available for the moth year round.

Given that:

- larvae and adults are mobile, at least to some degree;

- host plants are widely distributed in New Zealand in both domestic and commercial situations;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

P. heparana has established successfully in several countries in continental Europe that have cool-temperate climates. This indicates that climate is unlikely to be a barrier to it establishing in New Zealand. Since *P. heparana* overwinters during the larval stage, it would be able to hibernate when conditions became unfavourable (in autumn or winter, depending in which region of New Zealand it is situated), and resume feeding once conditions become favourable (spring or summer).

P. heparana reproduces sexually. Multiple larvae may occur in a fruit since eggs are laid in masses. Simultaneous breaking of diapause would result in adults emerging at the same time, thereby increasing the likelihood of mating and a viable population establishing.

Given that:

- *P. heparana* reproduces sexually, but multiple larvae in a fruit will increase the likelihood of mating;
- hosts are widely distributed;
- climate is unlikely to be a barrier to establishment;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

P. heparana occurs in mixed populations with other closely-related species (Dickler, 1991), making it difficult to assess its economic impact. Larvae of *P. heparana* could cause damage to fruit of many important host plants in New Zealand, for example, apples and pears. Feeding by summer generation larvae on foliage and shoots causes little significant damage, but the larval stings and patch feeding on fruit of the autumn generation is of economic importance. It is considered to be one of the most important tortricid pests in Europe (Dickler, 1991).

If the pest was to establish in New Zealand, there may be an impact on market access, for pomes and stonefruit to countries where it is not established. There may also be adverse effects on market access if the pipfruit industry has to change from its current low chemical production regime.

Fruit trees in the Rosaceae are widely planted in domestic gardens and would likely to be adversely effected if *P. heparana* established in New Zealand.

Salicaceae trees are widely used throughout New Zealand as windbreaks, urban amenities or for erosion control. Defoliation of these trees could also have an adverse economic impact.
The potential economic consequences are considered to be high.

Environmental consequences

Host plants of P. heparana are widely distributed throughout New Zealand. Since *P. heparana* is highly polyphagous, there are a large number of plants in New Zealand that could be suitable hosts.

The potential environmental consequences are uncertain but considered to be low.

Human health consequences

There are no known human health consequences.

Risk estimation

The likelihood of *Pandemis cerasana* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for P. cerasana is negligible and it is not classified as a hazard in the commodity.*

The likelihood of *Pandemis heparana* entering New Zealand with *Pyrus* fresh produce from China is low, and the likelihood of exposure and establishment is moderate. The potential economic consequences are high. *As a result the risk estimate for P. heparana is non- negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

The distribution of these species within China is unknown. It is uncertain how far larvae will disperse to pupate. We assume that there will be host plants sufficiently close to discarded fruit for exposure to occur.

10.18.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area status

The distribution of *P. heparana* in China is not known.

Bagging of fruit

Adults have a wingspan of 16–25 mm (Dickler, 1991). Bagging of fruit is likely to prevent adult *P. heparana* from laying eggs on the surface of fruit. Bagging may not occur until four weeks after fruit set, and eggs could be laid during this period. However, such eggs would be first generation, and it is larvae from the second generation that are most likely to be transported in pear fruit. *Pyrus* sp. nr. *communis* fruit are not bagged, so this will not be an effective option for these fruit.

Phytosanitary inspection prior to export

Larvae are external and internal feeders; the holes made in fruit by larvae can be quite large and are likely to be easily seen.

Cold treatment

Since larvae overwinter, cold treatment is unlikely to be an effective option.

A combination of fruit bagging phytosanitary inspection would mitigate the risk to a higher degree than any measure in isolation.

10.19 *Pempelia heringii – pear fruit borer*

Scientific name: *Pempelia heringii* Ragonot, 1888 (Lepidoptera: Pyralidae)
Other relevant scientific names: *Nephopteryx rubrizonella* Ragonot
Common names: pear fruit borer, pear fruit worm

10.19.1 Hazard identification

New Zealand status

Pempelia heringii is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

In the spring young larvae of *Pempelia heringii* bore into newly developing buds, each larva injuring two to three buds. Towards the end of April, they bore into the young fruit, ejecting frass from the entry hole (Arakawa, 1927). Each larva may attack three to four fruit. First generation adults lay single eggs on fruit, which hatch after eight or nine days, and the larva bores into the mature fruit. In these larger fruit, the larva can attain maturity within a single fruit, pupating within it. The second generation adult does not lay eggs on the fruit, but deposits eggs singly on the buds or on bark near the buds. New larvae penetrate immediately into the buds, causing them to wither (Matsumoto, 1918).

In Japan, *P. heringii* has two generations per year (Arakawa, 1927; Matsumoto, 1918). Larvae mature in mid- to late May (spring). Pupation occurs in early to mid-June (mid-summer) and lasts for two weeks (Matsumoto, 1918; Arakawa, 1927). Pupation takes place within the fruit, which has been previously attached to the branch by silken threads. Adults emerge from end-June to mid-July (mid- to late-summer) and again from end-September to early-October (mid- to late-autumn) (Arakawa, 1927).

It appears that *P. heringii* overwinters either in the larval stage within the buds of pear (Matsumoto, 1918), or at the egg stage (Arakawa, 1927).

Hosts

Rosaceae: *Malus*, *Pyrus* (Arakawa, 1927; Matsumoto, 1918); *Crataegus pinnatifida* (Sun et al, 1992). It is uncertain which species of *Pyrus* these publications are referring to; however, as *P. heringii* is recorded from Japan and north-eastern China, it is assumed to be *P. pyrifolia*.

Plant parts affected

Leaves, bark, flowers and fruit (Arakawa, 1927; Matsumoto, 1918).

Geographical distribution

Asia: China (Sun et al, 1992; Zhang, 1994); Japan (Matsumoto, 1918; Zhang, 1994).

Within China, *P. heringii* has been recorded in Shandong (Sun et al, 1992) and 'north-eastern' China (Zhang, 1994).

Hazard identification conclusion

Pempelia heringii has been recorded on *Pyrus*, and is associated with the fruit and flowers of host plants. It is present in China. It is not known to be present in New Zealand, and is considered to be a potential hazard.

10.19.2 Risk assessment

Entry assessment

The eggs, larvae and pupae of *Pempelia heringii* are associated with the fruit of host plants.

The morphology of *P. heringii* is unknown. It is assumed to be similar in size to other members of this genus; adults of *Pempelia formosa* have a wingspan of 20–23 mm, and the wingspan of *Pempelia genistella* adults is 26–29 mm (Kimber, 2008).

The size of the larval entry holes and any consequent swelling or deformation of the fruit is unknown. However, the internal-feeding larvae are reported to eject excreta to the outer surface of the fruit and it is assumed that this frass would be visible during harvest. Eggs are laid singly on the surface of the fruit, and only by first generation adults, which would mean they are unlikely to be present on fruit at harvest. Pupae occur in fruit which are attached to the twig with silken thread. It is assumed that such fruit would be detected during harvest.

Given that:

- eggs and adults are unlikely to be associated with fruit at harvest;
- some fruit infested with larvae are likely to be detected and discarded during the harvest and packing process;
- fruit infested with pupae are bound to the twig with silk and likely to be detected and discarded during the harvest and packing process;

The likelihood of entry is considered to be low, but non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed throughout New Zealand’s city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. Pupation can occur in mature fruit. If an infested fruit was disposed of in an open compost bin, near a suitable host such as an apple or pear tree, the likelihood of emerging adults which are mobile, finding a host would be high.

Given that:

- infested fruit would need to be discarded in appropriate conditions for the pupa to complete its development;
- adults emerging from pupae are mobile;
- host plants are widely distributed in New Zealand in both domestic and commercial situations;

The likelihood of exposure is considered to be low but non-negligible.

Establishment assessment

Since *P. heringii* reproduces sexually, multiple larvae would need to enter and pupate in the same area, in order for an emerging adult to find an individual of the opposite sex and establish a population. Larvae occur singly on fruit, but if one fruit in a consignment is infested, other fruit may also be infested.

The lower temperature threshold of *P. heringii* is unknown, but since it occurs in countries with cool-temperate climates, e.g. Japan, it is assumed that climate is unlikely to be a barrier to it establishing in New Zealand.

Given that:

- *P. heringii* reproduces sexually, and larvae occur singly in fruit;
- climate is unlikely to be a barrier to establishment;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

There is little recent information about *Pempelia heringii*, therefore its current economic importance is unknown. *P. heringii* mostly attacks pears and apples. New Zealand has a large apple and pear industry, and establishment of *P. heringii* could lead to production losses. Since it's distribution is currently restricted to Asia, impacts on market acces for New Zealand's pipfruit might be expected. There may also be adverse effects on market access if the pipfruit industry has to change from its current low chemical production regime.
The potential economic consequences are uncertain.

Environmental consequences

Pempelia heringii is not known to be polyphagous, as records of hosts are all members of the subfamily Maloideae (or Pomoideae) of the Rosaceae family, in particular, apple, pear and hawthorn. There are no New Zealand native plants that are members of this group of the Rosaceae family.
The potential environmental consequences are negligible.

Human health consequences

There are no known human health consequences associated with *Pempelia heringii*.

Risk estimation

Pempelia heringii has a low likelihood of entry and a low likelihood of exposure and establishment in New Zealand. The potential economic impact within New Zealand is uncertain. *As a result the risk estimate for P. heringii is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There is little available information on the biology of *P. heringii*. It is not known whether pupae can complete their development in fruit that are not attached to the host tree. It is not known which species of *Pyrus* are hosts, or the scale of damage caused by the pest.

10.19.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest-free areas

The distribution of *P. heringii* in China is largely unknown; it is recorded in Shandong, and in 'north-east' China. Pest-free areas are not likely to be viable option for most fruit. However it may be a viable option for pears from some areas if its absence can be demonstrated. The main pear area where *P.* sp. nr. *communis* pears are grown for export is Xinjiang. Pest-free area status may be a viable option for these fruit if its distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

Bagging of fruit

Adults of other *Pempelia* spp. are relatively large, with a wingspan of over 20 mm. The practice of bagging individual fruit is likely to prevent adult females from laying eggs on the fruit surface. Bagging may not occur until four weeks after fruit set, and eggs could be laid during this period. However, such eggs would be first generation, and it is larvae from the second generation that are most likely to be transported in pear fruit. *Pyrus* sp. nr. *communis* fruit are not bagged, so this will not be an effective option for these fruit.

Phytosanitary inspection prior to export

The larvae are internal feeders; frass is ejected from the entry hole and a thorough inspection is likely to pick up fruit infestation by the larvae of this insect.

Cold treatment

There is no information on the temperature thresholds of *P. heringii* and the effect of cool storage on individuals is unknown.

10.20 *Peridroma saucia – pearly underwing moth*

Scientific name:	*Peridroma saucia* (Hübner, 1808) (Lepidoptera: Noctuidae)
Other relevant scientific names:	*Agrotis angulifera* Wallengren, 1860; *Agrotis inermis* Harris, 1841; *Agrotis impacta* Walker, 1857; *Agrotis intecta* Walker, 1857; *Agrotis ortonii* Packard, 1869; *Agrotis saucia* (Hübner); *Lycophotia margaritosa* (Haworth); *Lycophotia ochronota* Hampson, 1903; *Lycophotia saucia* (Hübner); *Noctua aequa* Hübner, 1813; *Noctua majuscula* Haworth, 1809; *Noctua margaritosa* Haworth, 1809; *Noctua saucia* Hübner, 1808; *Peridroma margaritosa* (Haworth); *Rhyacia margaritosa* (Haworth); *Rhyacia saucia* (Hübner)
Common names:	pearly underwing moth, variegated cutworm

10.20.1 Hazard identification

New Zealand status

Peridroma saucia is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

The larvae of *Peridroma saucia* have been recorded on a wide range of more than 130 angiosperms, preferring primarily herbaceous dicotyledonous plants, then woody shrubs and low-growing fruit trees, and thirdly monocotyledonous plants, mainly grasses. As a result, the species primarily inhabits open, disturbed areas where a wide range of host plants is available. Damage to crop species is more severe in areas where weedy plants grow adjacent to or among the crop plants. The migratory habits of the moths result in the species occurring in many remote areas that have been opened for agriculture (CPC, 2007).

P. saucia is considered to be a minor agricultural pest in most of Europe and eastern Asia, but is a more significant pest in southern Europe (for example, Italy) and in greenhouses on such crops as peppers and globe artichoke. It is a major pest in most of the USA, especially on potato, tomato, tobacco and lucerne, but estimates of financial loss are rarely reported. (CPC, 2007). High densities can occur in apple orchards in the USA, with fruit damage to about 50% of the entire crop in one instance by the end of August (Rock and Waynick, 1975). The damage was conspicuous with in some cases almost the entire fruit being consumed.

Variegated cutworms overwinter as pupae with a high percent mortality occurring during this life stage. Female moths emerging from surviving pupae compensate by laying over 2000 eggs during their short life span. Clusters of 60 or more eggs are deposited on stems or leaves of slow-growing plants as well as on fences and buildings. During the summer, eggs usually hatch in 5 days. Young larvae are active during the day, but once they reach their fourth instar, they feed only at night. The larvae feed for about 3½ weeks before burrowing into the soil to pupate. The non-overwintering pupal stage lasts 2 weeks to a month before second generation moths emerge. Requiring 48 days to complete a life cycle, variegated cutworms produce two to four generations each year depending on weather conditions and latitude (Sorensen and Baker, 2008). A wide variety of parasitoids have been reared from *P. saucia* (CPC, 2007).

In China, there are two to three generations per year. Larvae infest several low-lying food crops, feeding on leaves (Kuang, 1985). Fully-grown larvae overwinter in the soil in depths of up to 10 cm. Adult emergence occurs during darkness and mating occurs four days afterwards. Female adults lay 200–500 eggs but some lay up to 1000, on the ground or on weeds surrounding the host plants.

Larvae attack fruit as well as the leaves of tomato and feed on stems or bark if leaves are not available (Bibolini, 1970). Damage to melon and water melon fruits in Italy consists of a combination of surface erosions and deeper holes extending to the endocarp, within which larvae were often found. Fruits are infested at all developmental stages, and the intensity of damage increased with the increase in the number and size of larvae. Up to 3–4 larvae per fruit were found, usually feeding on fruit surfaces (Sannino et al, 2007).

Hosts

The larvae of *P. saucia* feed on a wide range of herbaceous plants, both weedy and agriculturally important species such as *Brassica* spp. (CPC, 2007). Woody shrubs and trees including *Pyrus communis* are reportedly minor hosts CPC (2007).

Plant parts affected

Leaves, stems (CPC, 2007). Fruit of tomatoes (Bibolini, 1970), apples (Rock and Waynick, 1975), melon and watermelon (Sannino et al, 2007), peach (Pucci and Paparatti, 1987).

Rings and others (1976) compiled a worldwide annotated bibliography of this species. From the hundreds of sources reviewed, it appears that *P. saucia* is primarily a foliage feeder. However, a number of papers in the bibliography suggest that when an outbreak occurs, the larvae are indiscriminate feeders. For instance, Smith (1932) is quoted as reporting ‘some rather unusual damage by variegated cutworms occurred in the horticultural orchard during 1931. The outbreak started in a field of vetch. The larvae climbed the grape vines, damaged the grape foliage severely, and ate off many small bunches of developing grapes. Others climbed the apple trees, ate the bark in places and the young apples on the trees.’ No specific reference was found in the bibliography of *P. saucia* being associated with pear trees or feeding on pear fruit. There is a single reference stating that it was collected in a light trap in an apple or pear orchard in Italy (Pucci and Paparatti, 1987)

Geographical distribution

P. saucia occurs throughout much of Europe, in North, Central and South America, North Africa and parts of Asia: Armenia (CPC, 2007); China (CPC, 2007; Kuang, 1985); Taiwan, Israel, Japan, Sri Lanka, Syria, Turkey (CPC, 2007).

Hazard identification conclusion

Pyrus spp. are reported to be minor hosts for *Peridroma saucia*. It has a reported association with the fruit of some hosts. It is not known to occur in New Zealand and is considered a potential hazard.

10.20.2 Risk assessment

Entry assessment

Peridroma saucia is primarily a foliage feeder. There are reports of larvae feeding on fruit of orchard trees in the event of population outbreaks. No records of such an event on *Pyrus* have been found and they are assumed to be rare, if they occur at all. Large numbers are likely to be present in such situations and the presence of the pest in the orchard would be very evident. Given that an outbreak would be an unusual and obvious event, it is very unlikely that infested fruit would be harvested.

The likelihood of entry is considered to be negligible.

Risk estimation

Peridroma saucia has a negligible likelihood of entry. *The risk estimate for P. saucia is negligible and it is not classified as a hazard on the commodity. Therefore risk management measures are not justified.*

Note that although *Peridroma saucia* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

The association between the larvae of *Peridroma saucia* and mature fruit of *Pyrus* is uncertain.

10.21 *Spilonota spp. – Tortricid moths*

Scientific name: *Spilonota albicana* (Motschulsky) (Lepidoptera: Tortricidae)
Other relevant scientific names: *Tmetocera prognathana*
Common names: large apple fruit moth

Scientific name: *Spilonota lechriaspis* (Meyrick, 1932)
Other relevant scientific names: *Eucosma lechriaspis* (Meyrick)
Common names: apple fruit licker, bud moth

Scientific name: *Spilonota ocellana* (Denis and Schiffermüller, 1775)
Other relevant scientific names: *Eucosma ocellana* Denis and Schiffermüller; *Grapholita ocellana* Denis and Schiffermüller; *Hedya ocellana* Denis and Schiffermüller; *Olethreutes ocellana* Denis and Schiffermüller; *Tmetocera ocellana* Denis and Schiffermüller; *Tortrix ocellana* Denis and Schiffermüller
Common names: eye-spotted bud moth

10.21.1 Hazard identification

New Zealand status

Spilonota albicana, *S. lechriaspis* and *S. ocellana* are not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

Spilonota albicana
Larvae of *S. albicana* have reportedly reduced the yield of some apple orchards in Russia by up to 85% (Ovsyannikova and Grichanov, 2008a). Larvae of *S. albicana* overwinter in bark crevices or leaf litter, and pupate in the same place in the spring. Newly-hatched larvae feed on leaves, buds and flowers, mainly in plaited leaves. Spring generation larvae develop in 25–30 days and the pupal stage lasts about 20 days. Summer generation moths lay eggs mainly on fruit. The larvae penetrate the fruit most commonly at the calyx and less often at the base of the pedicel or side of the fruit. They gnaw out chambers in the fruit. A spot or swelling on the surface of the fruit forms due to the build-up of frass internally. Older larvae leave the fruit to overwinter (Ovsyannikova and Grichanov, 2008a).

In the Amur Region of Russia, there are two generations of *S. albicana*. First generation adult flight occurs mid-May to June and the second generation flies from mid-July to end-August. Larvae of the first generation appear at the end of May and larvae of the second generation complete development and abandon the fruit from the end of August (Ovsyannikova and Grichanov, 2008a).

Spilonota lechriaspis
There are one to two generations in a year in Korea. Larvae of *S. lechriaspis* emerge in spring and are destructive to the buds of their host plant. Later, they move to the leaves and feed inside a rolled leaf and retard the development of new twigs (Nakayama, 1937b).

Adults occur from June to August. The female moths reportedly lay 10–79 eggs, at night. Larvae hatch after 4–6 days (Nakayama, 1937b). Larvae hibernate, usually in the fourth instar, in a nest of dead leaves that they have severed (Nakayama, 1937b).

There are two generations in Japan. Overwintered larvae begin feeding in early April and adults emerge from late May-early June and from early July to early October (Iwasa and Matsumoto, 1938).

Spilonota ocellana

S. ocellana is univoltine in the northern part of its range and bivoltine further south and at lower altitudes (Ovsyannikova and Grichanov, 2008b). In the pear orchards of Hopei (Hebei), China, there is one generation of *S. ocellana*. Twelve-day-old larvae feed on leaves and buds then overwinter until spring (April) (Chang and Lin, 1939) under bud and bark scales and in leaf residues bound to the branches. The spring generation larvae gnaw through leaf petioles, flower and fruit pedicels and bind the damaged foliage into bunches. Pupation occurs in these webs or under bark scales and lasts 9–15 days. The adult female lays eggs singly or in groups of 3–5 on the upper side, and less often on the lower side of leaves and occasionally on fruits (Ovsyannikova and Grichanov, 2008b). Females lay 50–200 eggs (Meijerman and Ulenberg, 2000). The eggs develop in 8–12 days at 20°C and 50% relative humidity. Summer larvae develop in tubules of plaited leaves bound to the surface of the fruit (Ovsyannikova and Grichanov, 2008b) and larvae feed on the surface of the fruit on apple and pear trees (Meijerman and Ulenberg, 2000).

There is one generation of *S. ocellana* in the pear, apple and peach orchards of Spain. Larvae feed on leaves, fruit and buds during the summer season (Cabezuelo Perez and Hernandez, 1973).

Leaves, buds and fruit are damaged by *S. ocellana* (Cabezuelo Perez and Hernandez, 1973; Chang and Lin, 1939; CPC, 2007). The damage caused by larvae is sufficient to lower the commercial grade of fruit and result in loss of yield. The extent of yield losses is variable. Up to 75% loss of apple yields has been reported in Azerbaijan and Tadjikistan. High numbers of larvae can occur in fruits in August and September (Ovsyannikova and Grichanov, 2008b). High populations of larvae feeding on developing fruit cause early fruit drop and scarring of fruit (Meijerman and Ulenberg, 2000). Young plantings of apple and pear are most susceptible to infestation by *S. ocellana* (Ovsyannikova and Grichanov, 2008b).

Hosts

All three *Spilonota* species are pests of Rosaceous hosts:

S. albicana:

A polyphagous pest of rosaceous fruit and forest species: *Crataegus* sp., *Cotoneaster* sp., *Cerasus* sp., *Malus* sp., *Prunus avium*, *Prunus dulcis*, *Prunus persica*, *Pyrus ussuriensis* (Ovsyannikova and Grichanov, 2008a); *Pyrus pyrifolia*, *P. bretschneideri* (AQSIQ, 2007).

S. lechriaspis:

Rosaceae. *Malus* sp., *Pyrus* sp., *Pyracantha* sp. (Meijerman and Ulenberg, 2000; Nakayama, 1937b; Yang, 1998; Yuan et al, 2000); *Pyrus pyrifolia*, *P. bretschneideri* (AQSIQ, 2007).

S. ocellana:

A polyphagous pest of rosaceous fruit trees and many wild growing trees in other families such as hazel, birch, willow, maple, and alder (Ovsyannikova and Grichanov, 2008b). *Malus domestica* (CPC, 2007; Cabezuelo Perez and Hernandez, 1973; Meijerman and Ulenberg 2000); *Prunus avium*, *Prunus domestica*, *Prunus persica* (CPC, 2007; Meijerman and Ulenberg, 2008); *Pyrus communis* (CPC, 2007; Cabezuelo Perez and Hernandez, 1973; Meijerman and Ulenberg, 2000); *Rosa canina, Rubus fruticosus, Rubus idaeus, Vaccinium myrtillus* (CPC, 2007); *Pyrus pyrifolia*, *P. bretschneideri* (Biosecurity Australia, 2005).

Plant parts affected

S. albicana:

Leaves, buds, flowers and fruit (Ovsyannikova and Grichanov, 2008a).

S. lechriaspis:

Buds and leaves (Nakayama, 1937b).

S. ocellana:

Leaves, buds and fruit (Cabezuelo Perez and Hernandez, 1973; Chang and Lin, 1939; CPC, 2007).

Geographical distribution

S. albicana:

Asia: China (Northeast), Korea, Japan, Russia (Ovsyannikova and Grichanov, 2008a).

S. lechriaspis:

Asia: China (Northeast) (Yang, 1998; Yuan et al, 2000; Zhang, 1994); Japan, Korea (Nakayama, 1937b); Russia (Meijerman and Ulenberg, 2000). Within China, *S. lechriaspis* has been recorded in Shandong (Shen, 1997) and Liaoning (Chao, 1980)

S. ocellana:

Asia: Within China, *S. ocellana* has been recorded in Heilongjiang, Liaoning, Shandong and Hebei (Bai, 1983); Japan, Korea, Russia (Bai, 1983); Turkey (CPC, 2007).
Europe: Albania, Belgium, Bulgaria, Finland, France, Germany, Hungary (CPC, 2007); Italy (Cabezuelo Perez and Hernandez, 1973); Lithuania, Netherlands, Poland, Romania (CPC, 2007); Russia (Zhang, 1994); Spain, UK (CPC, 2007).
North America: Canada, USA (Meijerman and Ulenberg, 2008; CPC, 2007).

Hazard identification conclusion

Spilonota albicana and *S. ocellana* have been recorded on *Pyrus*, and are associated with the fruit of host plants. They are both present in China and are not known to be present in New Zealand. They are considered to be potential hazards.

Spilonota lechriaspis has been recorded on *Pyrus*, but no evidence has been found that it is associated with the fruit of host plants. It is not considered to be a potential hazard.

10.21.2 Risk assessment

Entry assessment

Spilonota albicana

First generation larvae feed on the surface of younger fruit. Summer generation larvae bore into the fruit, usually through the calyx. Although the larvae may not be visible inside the fruit, the entry and exit holes that they create are large enough to be detected. Furthermore, the fruit changes shape and swells as larvae feed internally and congest it with web frass (Ovsyannikova and Grichanov, 2008a). The number of larvae remaining in the fruit at harvest will depend on the type of fruit and locality. *Pyrus pyricola* and *P. bretschneideri* are harvested later than *P.* sp. nr. *communis* (see Chapter 2). It is expected some infested fruit would be detected and discarded during the harvest and packing process. Mature larvae of *S. albicana* are able to overwinter in Russia suggesting that larvae inside the fruit would be able to survive the storage and transportation of the commodity.

Eggs of *S. albicana* are transparent and elliptical. They are laid on the fruit and up to 300 eggs can be laid by a single female (Ovsyannikova and Grichanov, 2008a; Tikhonov, 1962). It is not known if they are laid singly or in masses, but it is assumed to be similar to *S. ocellana*, which lays eggs in groups of three to five. Eggs are unlikely to be present on the fruit at harvest, unless late flying second generation adults are present.

Pupae and adults are unlikely to be associated with fruit.

Spilonota ocellana

Adults and pupae of *S. ocellana* are not associated with fruit, and eggs are laid on the leaves; larvae can be associated with fruit. They are 9–12 mm long and dark red brown in colour, therefore are visible to the naked eye (CPC, 2007). Leaves are the usual feeding site and the larvae of *S. ocellana* use a silken web to spin leaves together; however, as with many other tortricids, if there is fruit in the vicinity, larvae may feed on the surface of the fruit. This causes shallow, irregular tunnels and tiny holes in the skin in apples and pears (Meijerman and Ulenberg, 2000; Ministry of Agriculture and Lands, 2006). Many larvae would be expected to have left the fruit prior to harvest and since damaged fruit is scarred it would be expected to be commercially downgraded, and not exported.

Given that:

- larvae of both species are likely to be present in fruit at harvest, but *S. albicana* may have left late harvested fruit;
- larvae of *S. albicana* feed inside the fruit, while those of *S. ocellana* are less often associated with fruit and are surface feeders;
- the evidence of larval feeding is expected to be visible, but may be missed if the populations are at a low level;

The likelihood of entry of Spilonota albicana is considered to be low to moderate and S. ocellana very low and therefore non-negligible.

Exposure assessment

Fresh, infested *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and often the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed, especially if the fruit are damaged or infested. Both *Spilonota* species have a range of hosts, which are common in gardens and orchards throughout New Zealand. It is assumed that any eggs present on fruit at harvest would hatch prior to disposal in New Zealand. The effect of seasonal inversion on larvae entering New Zealand in pears is unknown, but it is assumed that they would disperse from discarded fruit and be able to complete their life cycle.

Given that:

- larvae and adults are mobile, at least to some degree;
- host plants are widely distributed in New Zealand in both domestic and commercial situations;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

Male and female individuals would need to arrive together and develop to adults in order for a population to establish. Eggs are laid in small groups, which may increase the likelihood of multiple larvae arriving. *S. ocellana* produce pheromones (Ovsyannikova and Grichanov, 2008b) which are likely to facilitate males and females finding each other.

Warm conditions favour the development of *Spilonota* spp. larvae, by reducing the time required for development. Although *Spilonota* spp. prefer warm climates, they have established successfully in Asian, and continental and Eastern European countries where there are cool-temperate climates, and it is assumed that climate would not be a barrier to establishment in New Zealand. In addition, both *Spilonota* spp. overwinter at the larval stage, therefore *S. albicana* and *S. ocellana* would have the ability to hibernate as conditions become unfavourable, and then resume feeding in the spring.

The reported host range of *S. albicana* and *S. ocellana* is wide. In New Zealand, a number of host species grow wild and are also widely cultivated, so there would be no shortage of suitable hosts that would limit S. *albicana* and *S. ocellana* establishing in New Zealand.

Given that:

- both species reproduce sexually, but clumped distribution and production of pheromones will increase the likelihood of mating;
- hosts are widely distributed;
- climate is unlikely to be a barrier to establishment;

The likelihood of establishment is considered to be moderate and therefore non-negligible.

Consequence assessment

Economic consequences

The direct impact of *Spilonota ocellana* is difficult to assess as it frequently occurs in mixed populations (Kot and Jaskiewicz, 2006; Matis et al, 2003). Nonetheless, both *Spilonota albicana* and *S. ocellana* can cause significant crop losses in the countries where they exist. Pip- and stone-fruit production is likely to be affected should these species establish in New Zealand.

S. albicana has a restricted distribution and if it were to establish in New Zealand, there may be an impact on market access for pomes and stonefruit to countries where it is not established.

Fruit trees in the Rosaceae are widely planted in domestic gardens and would likely to be adversely effected if either species established in New Zealand.

Salicaceae trees are widely used throughout New Zealand as windbreaks, urban amenities or for erosion control. Defoliation of these trees could also have an adverse economic impact.

The potential economic consequences are considered to be high.

Environmental consequences

Host plants of *Spilonota albicana* and *S. ocdellana* are widely distributed throughout New Zealand and in the case of S. *ocellana includes* species in families outside the Rosaceae. They are likely to be polyphagous on woody hosts with an unknown host range in New Zealand.

Human health consequences

There are no known human health hazards caused by *S. albicana* and *S. ocellana*.

Risk estimation

Spilonota albicana and *Spilonota ocellana* have a low to moderate and very low likelihood of entry respectively, a moderate likelihood of exposure and establishment in New Zealand. The potential economic impact within New Zealand is high. The risk estimate for *S. albicana* and *S. ocellana* is non-negligible and they are classified as hazards on the commodity. Therefore risk management measures can be justified.

Assessment of uncertainty

It is not known if the eggs of *S. albicana* are laid singly or in masses, but their biology is assumed to be similar to that of S. *ocellana*, which lays eggs in groups of three to five. It is not known how long eggs take to hatch, but it is assumed that any eggs present on fruit at harvest would hatch prior to the fruit entering in New Zealand. There is little information available on the distribution of these species within China; they are assumed to be widespread.

There is little information available on *S. lechriaspis.*

10.21.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by these organisms is assessed.

Pest free area

There is little information available on the distribution of these species within China, but they appear to have a north-east distribution. The main pear area where *P.* sp. nr. *communis* pears are grown for export is Xinjiang. Pest free area status may be a viable option for these fruit if its distribution can be verified in accordance with the requirements set out in ISPM Nos. 4 or 10 (see Section 4.4).

Bagging of fruit

The practice of individually bagging fruit on the trees is likely to prevent adults of *S. albanica* from laying eggs on the fruit, and will present a barrier to larvae of both species feeding on the fruit. Bagging may not occur until four weeks after fruit set, and eggs could be laid during this period. However, such eggs would be first generation, and it is larvae from the second generation that are most likely to be transported in pear fruit. *Pyrus* sp. nr. *communis* fruit are not bagged, so this will not be an effective option for these fruit.

Phytosanitary inspection prior to export

S. ocellana larvae feed on the surface of fruit. The damage is obvious and the first instar larvae are relatively large (up to 18 mm in length). Larvae of *S. albicana* are less obvious as they feed inside the fruit. However marking on the surface of the fruit should increase the likelihood of detection.

Cold treatment

Both species overwinter in the larval stage and there is no literature to suggest that cold treatment will be an effective mitigation option.

A combination of fruit bagging and visual inspection would mitigate the risk to a higher degree than either measure in isolation.

10.22 *Xestia c-nigrum – spotted cutworm*

10.22.1 Hazard identification

Scientific name:	*Xestia c-nigrum* (Linnaeus) (Lepidoptera: Noctuidae)
Other relevant scientific names:	*Agrotis c-nigrum* (Linnaeus); *Bombyx gothica* var. *nunatrum* Esper, 1786; *Bombyx gothica* var. *singularis* Esper, 1786; *Diarsia c-nigrum* Linnaeus; G*raphiphora c-nigrum* (Linnaeus); *Noctua c-nigrum* (Linnaeus); *Phalaena c-nigrum* (Linnaeus); *Phalaena noctua c-nigrum* Linnaeus, 1758; *Rhyacia c-nigrum* (Linnaeus); *Xestia adela* Franclemont, 1980
Common names:	spotted cutworm, black c-moth

New Zealand status

Xestia c-nigrum is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2008).

Biology

The larvae of *X. c-nigrum* feed on a wide range of herbaceous plants, both weedy and agriculturally important species. The species primarily inhabits open areas where wide ranges of host plants are available. Damage to crop species is more severe in areas where weedy plants grow adjacent to or among the crop plants (CPC, 2007).

There are one to three generations of *X. c-nigrum* per year, depending on the climate. In warmer climates such as southern Europe, there are three generations, but at higher elevations in Japan, there is only one (CPC, 2007). In northern Japan, the summer generation of *X c-nigrum* has six larval instars (Oku, 1985) and adults have two distinct flight periods in the plains and the lower hills, due to differences in temperature (Oku, 1984).

Females lay eggs singly or in masses of up to 100 eggs, in single layers. A total of 800 to 1500 eggs can be laid by a female in her lifetime (CPC, 2007), either in the soil or on the leaves of the host plant (Oku, 1984). Larvae hatch from eggs after 6–9 days in the spring and summer when temperatures average around 20°C, but up to 12 days in the autumn when temperatures average about 15°C (CPC, 2007).

The larvae spend the days sheltered in ground cover and feed nocturnally on tree fruits (TFREC, 2008). The larvae leave a chemical trail and often return to the same shoot to feed on successive days. In Russia, pupation took place in early June and adults emerged in early July and peaked in mid-July (Musich, 1976).

During the summer larvae normally pass through six (occasionally seven) stages (instars) before pupating. Larvae from the spring generation take about a month to reach maturity, but larvae from the autumn generation pass the winter in the larval stage and the number of instars is more variable. Larvae enter the winter in the early-to-middle instars but are usually in the fourth or fifth instar in the spring, suggesting that they continue to feed and grow under the snow during the winter. The larvae can be particularly damaging in the spring because they are large and feed on developing shoots and plant buds. The mature larva has a prepupal resting phase that lasts from 2 to 11 days (depending on mean temperature). Pupation occurs in the soil in silk-lined chambers (CPC, 2007). The pupal stage lasts for 3 weeks in warm weather, and for up to 5 weeks in early spring. Adults emerging from the pupa have a pre-oviposition period of 3 or 4 days in spring and summer and 4–6 days in the fall. Adults are nocturnal and generally live for 2-3 weeks. They are attracted to light, and their presence and abundance can be monitored with light traps and pheromone traps to attract males (CPC, 2007).

In Washington, overwintering larvae feed on fruiting buds or fruitlets of apples in the spring. Since mature larvae can last an entire season, they are able to damage the latest maturing apples through harvest (TFREC, 2008).

Hosts

X. c-nigrum has been recorded on a wide range of hosts, preferring primarily herbaceous dicotyledonous plants and low-growing shrubs, but occasionally feeding on fruit trees and grasses (CPC, 2007). *Vitis vinifera* is a major host (CPC, 2007). Other hosts include: *Allium cepa, Brassica oleracea, Citrus sinensis, Lycopersicon esculentum, Malus domestica, Phaseolus vulgaris, Prunus avium, Prunus persica, Pyrus communis, Zea mays* (Fujimura, 1976; CPC, 2007).

Plant parts affected

The larvae feed on developing shoots and plant buds (CPC, 2007); buds of grapevines (Dibble et al, 1979); fruiting buds or fruitlets of tree fruit hosts (TFREC, 2008).

Geographical distribution

X. c-nigrum has been recorded in North Africa, North and Central America, Europe and Asia. In China it has been recorded from Shaanxi, Shanxi, Yunnan and Zhejiang Provinces (Lu et al, 1995).

Hazard identification conclusion

Xestia c-nigrum has been recorded on *Pyrus*, and is associated with the fruit and flowers of host plants. It is present in China and is not known to be present in New Zealand. Although there is no reference available regarding the association of *X. c-nigrum* with *Pyrus* fruit, since the pest is associated with apple fruit, it is assumed that it also attacks *Pyrus* fruit. Thus, *Xestia c-nigrum* is considered to be a potential hazard on the *Pyrus* fruit from China pathway.

10.22.2 Risk assessment

Entry assessment

Eggs, pupae and adults of *Xestia c-nigrum* are not associated with fruit. Mature larvae are large; 30–35 mm long and 6–7 mm wide (CPC, 2007), pale yellow-brown or pale grey, with several speckles and the dorsal half is dark brown. They would be visible to the naked eye, as would the feeding wounds on fruit.

The larvae are external feeders, feeding on fruit trees only at night and returning to ground cover to hide during the day. They are unlikely to be associated with the fruit during harvest (daytime). It is highly unlikely that *X. c-nigrum* will remain with the fruit of *Pyrus* on the pathway from China to New Zealand.

Given that:

- only the larvae are associated with the fruit;
- they are unlikely to be associated with the fruit during the harvest;
- the larvae and their damage are readily visible;

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of *Xestia c-nigrum* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for X. c-nigrum is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *Xestia c-nigrum* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

Assessment of uncertainty

There is little information on the feeding behaviour of *Xestia c-nigrum* on *Pyrus*, but it is assumed to be similar to its behaviour on other hosts.

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11 *Risk analysis of potential hazard organisms: Insecta: Thysanoptera*

11.1 *Caliothrips fasciatus North American bean thrips*

11.1.1 Hazard identification

Scientific name: *Caliothrips fasciatus* (Pergande) (Thysanoptera: Thripidae)
Other scientific names: *Euthrips fasciatus, Heliothrips fasciatus, Hercothrips fasciatus*
Common name: North American bean thrips

New Zealand status

Caliothrips fasciatus is not known to be present in New Zealand (not recorded in PPIN 2008; Mound and Walker, 1982).

Biology

Caliothrips fasciatus is a tiny, polyphagous thrips. It damages a variety of fruit and vegetable crops and weeds in the USA, where it originates. It usually feeds on leaves and young shoots, but some adults over-winter inside the navel of navel oranges from early November to late March (Bailey, 1933), and among many secondary host plants such as *Lactuca scariola* and *Sonchus* spp. (Schrock, 1938). The adults are quiescent and only break dormancy when winter temperatures reach approximately 24-27ºC for short periods (Bailey, 1933).

In cotton crops, the eggs of *C. fasciatus* are deposited in the petioles and leaves, with nymphs and adults feeding on both surfaces of the latter (Reiniger, 1947). The average number of eggs laid is 35 per female (Russell, 1912). The larvae usually drop to the ground to pupate at a depth of 7-15cm when soil temperatures are low enough to enable survival. In early observations in California, the entire lifecycle was completed in 84 days, allowing 7 generations per year; 5 full generations and 2 smaller generations (Russell, 1912).

C. fasciatus takes flight or jumps readily if disturbed (Russell, 1912).

Plant associations

C. fasciatus has been reported from *Vicia faba* (broad beans), *Medicago sativa* (lucerne), *Phaseolus* spp. (beans) and members of the Leguminosae (pea family) including *Pisum sativum*. Navel oranges are used as an overwintering site (Hoddle *et al.* 2006).

C. fasciatus has been reported on *Pyrus communis* (Lewis, 1929); *Pyrus* (Hua, 2000). It has also been recorded on *Argemone alba* var *glauca*, *Asparagus densiflorus* (Asparagus fern), *Beta vulgaris* (beets, swiss chard), *Brassica oleracea* (cabbage, cauliflower, kale), *Brassica rapa* (turnips), *Diospyros kaki* (persimmon), *Ficus* spp. (fig), *Gossypium* spp. (cotton), *Lactuca scariola* (prickly lettuce), Lactuceae (lettuce family), *Lycopersicon esculentum* (tomato), *Olea europea* (olive), *Persea americana* (avocado), *Prunus dulcis* (almond), *Pyrus* spp. (pear), *Raphanus sativus* (radishes), *Solanum* spp. (potato), *Sonchus* spp. (sow thistle) *Trifolium pratense* (red clover), *Vitis vinifera* (grapes) and *Zea mays* (corn- young shoots) (CAB International 2009; Hoddle *et al.* 2006 from Bailey 1933,1937 and 1938; Flaherty *et al.* 1992). There is a more extensive host list compiled from Baileys' 1933, 1937 and 1938 papers provided in Hoddle *et al*. (2006), but it is uncertain if *C. fasciatus* will feed or breed on all of the plants that were listed.

Plant part affected

C. fasciatus is found on leaves, buds, flowers and fruit of various plants (Sakimura and Krauss, 1944; Hoddle *et al.* 2006). It has been reported from pear fruit (*Pyrus communis)* (Lewis, 1929).

Geographic distribution

Caliothrips fasciatus has been reported from Florida up to Idaho and California, Hawaii and New York in the USA (Mound, 2008; Hoddle *et al.* 2006). It is also recorded from western Mexico (Hoddle *et al.* 2006) and Argentina (Blanchard, 1936; Levi *et al*.1975; Ziller *et al*. 2005).
In China, it has been reported from Fujian and Guangdong (Han,1997), Hubei, Sichuan (Hua, 1998).

Hazard identification conclusion

Caliothrips fasciatus has been reported from *Pyrus* fruit. It is present in China and is not known to be present in New Zealand. It is considered to be a potential hazard.

11.1.2 Risk assessment

Entry assessment

Caliothrips fasciatus has been reported from Fujian, Guangdong, Hubei and Sichuan in China. These are not the main provinces which grow pears for export, and prevalence in export orchards is not likely to be high. The only evidence found for an association with pears comes from California in the 1920s on *Pyrus communis*. Adults and larvae punctured the skin and sucked the juices from both fruit and leaves, focusing on tender foliage. The fruit scarred as it ripened rendering it unsuitable for export. It has been suggested that the presence of the preferred host *Lactuca scariola*, a common weed was a factor in its prevalence in these orchards (Lewis, 1929). *C. fasciatus* takes flight or jumps readily if disturbed. Over-wintering thrips are likely to be less mobile, but there is no evidence that they over-winter on pear fruit.

Given that:

- prevalence in export orchards is not likely to be high;
- C. fasciatus has only been reported from *Pyrus communis* (which is not one of the pear species proposed for export) and only in particular orchard circumstances in California;
- Any fruit that are affected are scarred and likely to be detected and discarded through the harvest and packing processes;
- thrips present on harvested fruit are not likely to remain on the fruit during the harvest and packing processes.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of C*aliothrips fasciatus* entering New Zealand with *Pyrus* fresh produce from China is negligible. *As a result the risk estimate for C. fasciatus is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified*.

Note that although *C. fasciatus* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a 'regulated pest'. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

11.2 *Thrips flavus* – *honeysuckle thrips*

Scientific name:	*Thrips flavus* Schrank, 1776 (Thysanoptera: Thripidae)
Other relevant scientific names:	*Physothrips flavidus* Bagnall; *Physothrips flavus* Bagnall; *Taeniothrips clarus* Moulton; *Taeniothrips luteus* Oettingen; *Taeniothrips rhopalantennalis* Shumsher; *Taeniothrips saussureae* Ishida; *Taeniothrips sulfuratus* Priesner; *Thrips biarticulata* Priesner; *Thrips flavidus* Bagnall; *Thrips flavosetosus* Priesner; *Thrips kyotoi* Moulton; *Thrips melanopa* Schrank; *Thrips nilgiriensis* Ramakrishna; *Thrips obscuricornis* Priesner; *Thrips ochraceus* Curtis
Alternate spelling:	*Thrips flava*
Common names:	Eurasian yellow flower thrips, cucurbit thrips, honeysuckle thrips

11.2.1 Hazard identification

New Zealand status

Thrips flavus is not known to be present in New Zealand. Not recorded in: Mound and Walker (1982), PPIN (2008).

Biology

Thrips flavus can reproduce both sexually and parthenogenetically. It is polyvoltine, producing about 8–10 generations annually. Copulation takes place 1–2 days after emergence, usually when temperatures are between 17–23˚C (Veer, 1985). Fertilised females lay 13–17 batches of eggs, with each batch containing 1–15 eggs. Unfertilised females lay 15–19 batches of eggs, with 1–10 eggs per batch. Eggs are laid in plant tissue, in the basal portion of petals, walls of the ovary or on the underside of leaves (Veer, 1985).

Larvae feed on the flowers and leaves for 3–5 days, then drop to the soil to pupate (Veer, 1985). Two to three days later the adults emerge. From egg to adult takes 9–17 days for males and 13–21 days for females. Female longevity is 31–33 days (Veer, 1985).

Damage to plants is largely caused by the adults and larvae sucking the sap from the leaves, shoots, petals and ovaries of host plants. In Taiwan, this results in stunting of shoots, retarding of terminal growth, yellowing of leaves, wilting of flowers and scarring of fruit of cucurbits (Wen and Lee, 1982). In India, Veer (1985) recorded necrotic silvering of leaves, scarring, curling and whitening of leaves, early senescence or deformation of inflorescences. In Spain, *T. flavus* damaged *Citrus* spp., causing ~60% of the fruit to be unsaleable in some orchards (Garcia et al, 2003). Sharma and Bhalla (1963) recorded the dropping of 40% of apple blossoms due to *T. flavus*. Fruit either did not set or dropped prematurely (Sharma and Bhalla, 1963). It is also thought to vector some economically important crop diseases such as viral mosaic disease of beans and watermelon bud necrosis (CPC, 2007).

Hosts

T. flavus is a highly polyphagous species. It is known to feed on *Pyrus communis* (Verma, 1979; CPC, 2007) although it is unclear whether young fruit as well as flowers are attacked. The host list also includes a range of vegetables, fruits and ornamental plants (CPC, 2007; Wen and Lee, 1982; Garcia et al, 2003;Veer, 1985; Verma, 1979).

Plant parts affected

T. flavus feeds on flowers, vegetables, leaves and ornamentals (Mound, 2007). Fruit of *Citrus* spp. (Garcia et al, 2003); shoots, flowers (Wen and Lee, 1982); leaves, flowers (CPC, 2007).

Geographical distribution

T. flavus is reported from Europe, Australia and Asia (CPC, 2007). In China, it is recorded from Guangdong Province (Huang et al, 2004).

Hazard identification conclusion

Thrips flavus is present in China and is not known to be present in New Zealand. It has been reported on *Pyrus* spp. and on fruits of some hosts. It is considered a potential hazard.

11.2.2 Risk assessment

Entry assessment

There are no reports in the literature of an association between *T. flavus* and mature *Pyrus* fruit. It is primarily a flower feeding thrips, although it can cause reduced fruit set or fruit to drop prematurely. It has not been reported from the main pear growing regions of China and is unlikely to be prevalent in pear orchards.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of entry for *T. flavus* is negligible. *As a result the risk estimate for T. flavus is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *T. flavus* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a ‘regulated pest’. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

11.3 *Thrips hawaiiensis* – *Hawaiian flower thrips*

Scientific name: *Thrips hawaiiensis* (Morgan, 1913) (Thysanoptera: Thripidae)

Other relevant scientific names: *Euthrips hawaiiensis* Morgan, 1913; *Physothrips hawaiiensis* (Morgan); *Physothrips pallipes* Bagnall, 1914; *Taeniothrips eriobotryae* Moulton, 1928; *Taeniothrips hawaiiensis* (Morgan); *Taeniothrips pallipes* var. *florinatus* Priesner, 1938; *Taeniothrips rhodomytri* Priesner, 1938; *Thrips albipes* Bagnall, 1914; *Thrips hawaiiensis* form *imitator* Priesner, 1934; *Thrips nigriflava* Schmutz, 1913; *Thrips pallipes* Bagnall, 1926; *Thrips sulphurea* Schmutz, 1913; *Thrips versicolor* Bagnall, 1926

Common names: Hawaiian flower thrips, banana flower thrips

11.3.1 Hazard identification

New Zealand status

Thrips hawaiiensis is not known to be present in New Zealand. Not recorded in: PPIN (2008), Mound and Walker (1982). There is one record from Campbell Island, which stated "seemingly represents *hawaiiensis*", which casts some doubt on the identification. Mound and Walker (1982) discuss this record and state that "the species is unlikely to survive in New Zealand, and particularly not in the subantarctic islands, but is widespread and abundant in tropical regions from India to Queensland" (Mound and Walker, 1982).

Biology

Thrips hawaiiensis is a common, polyphagous flower thrips, about 1.2 mm long. It can reproduce sexually and asexually with population numbers peaking when suitable host plants are flowering (CPC, 2007). When the host species is no longer flowering this thrips moves to another host (Cheng, 1985).

At 15–25°C survival rates from egg hatch to adult were above 79% when *T. hawaiiensis* was raised on a diet of pollen and honey solution. The mean fecundity on this diet was 537 eggs per female at 20˚C (Murai, 2001). The development time from egg to adult can take about 30 days but significantly longer at lower temperatures. Murai (2001) found that 154 degree-days above a base temperature of 10˚C were required to complete the life cycle from egg to adult oviposition in Japan. *T. hawaiiensis* has more than 20 overlapping generations per year in southern Taiwan (Tang, 1974), and Murai (2001) estimated 11–18 could occur outdoors in Western Japan.

The strong association with flowers means that *T. hawaiiensis* can act as a pollinator for some species, especially oil palms. However, in Taiwan and India it causes damage to *Citrus* by feeding at the base of the anthers, and on the developing ovules, causing fruit set failure (Chiu et al, 1991; Srivastava and Bhullar, 1980). It also damages blooms in the cut flower trade. On bananas, *T. hawaiiensis* causes scarring and corky scabs affecting fruit quality. Palmer and Wetton (1987) note that adults and larvae feed within flowers on pollen and sap, causing bud malformation and poor fruit set; and on the skin of young fruit, causing scarring. Reynaud and others (2008) state that *T. hawaiiensis* causes damage by puncturing flowers and fruit, and inducing spot lesions, scarring, necrosis or malformations depending on the severity of the attack. It also feeds on pollen and contributes to host plant fertility problems.

Hosts

T. hawaiiensis is polyphagous and has been recorded from 141 plant species in Taiwan alone, although it was not breeding on all of them (Chang, 1995). It has a preference for plants in the Fabaceae and Convolvulaceae families (Mau and Martin, 1993), and at least 25 different crops have been recorded as being attacked. *Pyrus* species have been recorded as hosts (Manzari and Golmohammadzadeh-Khiaban, 2000; Palmer and Wetton, 1987), as have apples (Palmer and Wetton, 1987).

Plant parts affected

Flowers (CPC, 2007); flowers, young fruit of *Citrus* sp. (Chiu et al, 1991).

Geographical distribution

T. hawaiiensis has been recorded from parts of Africa, North America, Central America, Oceania and Asia (CPC, 2007).

T. hawaiiensis is widespread in China, and is recorded from Guangdong, Guangxi, Hainan, Hong Kong, Jiangsu, Sichuan, Taiwan, Xizhang (Tibet), Yunnan and Zhejiang (CPC, 2007).

Hazard identification conclusion

Thrips hawaiiensis is present in China and is not known to be present in New Zealand. It has been reported on *Pyrus* spp. and on fruits of some hosts. It is considered a potential hazard.

11.3.2 Risk assessment

Entry assessment

There are no reports in the literature of an association between *T. hawaiiensis* and mature *Pyrus* fruit and it is primarily a flower feeder. *Pyrus* spp. do not appear to be major hosts.

The likelihood of entry is considered to be negligible.

Risk estimation

The likelihood of entry, *T. hawaiiensis* is negligible. *As a result the risk estimate for T. hawaiiensis is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Note that although *T. hawaiiensis* is not assessed as a hazard on this pathway and therefore risk management measures over and above standard commercial practice are not justified, it remains a ‘regulated pest’. Therefore, if it is intercepted on any imported lots at the border the infested lot will be treated to ensure the pests are effectively controlled prior to release. Alternatively, the consignment shall be reshipped or destroyed at the importers option and expense.

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12 *Risk analysis of potential hazard organisms: Mites*

12.1 *Tarsonemus yali*

There have been several mites intercepted on pears entering New Zealand from China (Chapter 3). Most of the intercepted mites have no record of association with *Pyrus* spp. in the literature and many are identified only to genus level. *Tarsonemus yali* is assessed as a representative of this group of organisms

Scientific name: *Tarsonemus yali* Lin and Zhang, 2006 (Acarina: Tarsonemidae)
Common name: tarsonemid mite

12.1.1 Hazard identification

New Zealand status

Tarsonemus yali is not known to be present in New Zealand. Recorded as absent in: Lin and Zhang (2006).

Biology

Tarsonemus yali is a newly described species that was intercepted at the New Zealand border on *Pyrus bretschneideri* imported from China (Lin and Zhang, 2006). There is virtually no information available on its biology. *Tarsonemus* spp. are thought to subsist mainly on fungi (Jeppson et al, 1975) although *Tarsonemus confusus* and *T. bilobatus* have been reported causing damage to peach fruit in China (Wang et al, 1999).

Hosts

Although *T.yali* is not known to be a plant pest, or to feed on plant hosts, it has been intercepted at the New Zealand border on fresh Ya pear fruit from China (MAFBNZ, 2009; Lin and Zhang, 2006). This demonstrates that there must be a mechanism for it becoming associated with the supply chain.

Geographical distribution

There is little available information on the distribution of *T.yali* in China. The holotype was reportedly collected by J.Z. Lin in Taishan, Shandong province (Lin and Zhang, 2006).

Hazard identification conclusion

The interceptions at the New Zealand border of these mites on Ya pear fruit demonstrate an association with the commodity. *T.yali* occurs in China and is not known to be present in New Zealand, and is considered a potential hazard.

12.1.2 Risk assessment

Entry assessment

There have been six records of interceptions of *T.yali* at the New Zealand border on Ya pears imported from China. The specific biology of this species is not known, but it is likely to a dust, fungus or predatory mite. Since its association with the pathway appears to be opportunistic it can be regarded as a hitchhiker on the imported pears. The operation of the supply chain must enable contamination of the commodity.

The likelihood of entry is considered to be non-negligible.

Exposure assessment

Little is known about *T.yali*, making it difficult to assess the likelihood of exposure. However, it is apparently readily associates with the pathway and on arrival in New Zealand, the commodity will go to environments similar to those encountered in pack houses in China. There is no apparent reason that *T.yali* would not be able to leave the commodity and find suitable habitat nearby.

The likelihood of exposure is considered to be non-negligible.

Establishment assessment

It is difficult to assess the likelihood of establishment of *T.yali* in the absence of detailed information about its biology and eco-climatic tolerances. However, assuming it is associated with human environments it is likely to be able to establish at least in built environments in New Zealand

The likelihood of establishment is considered to be non-negligible.

Consequence assessment

The potential impacts of establishment cannot be assessed without further information on the biology of *T.yali*. *D*omestic mites, including house dust mites and storage dust mites, have been identified as causal agents of asthma and other hypersensitive reactions.
The potential impact within New Zealand is unknown, but likely to be non-negligible.

Risk estimation

The likelihood of entry, exposure and establishment for *Tarsonemus yali* is non-negligible. The consequences of the introduction of any of this species cannot be determined. *As a result the risk estimate T. yali is non-negligible and they are classified as hazards in the commodity. Therefore risk management measures can be justified.*

12.1.3 Assessment of uncertainty

As *Tarsonemus yali* is newly named, there is insufficient information available to support a detailed assessment of risk.

12.1.4 Risk management

Tarsonemus yali is not known to be a pest of pears, and the stage of the supply chain at which it associates with the pathway is not known. The risk management options that are relevant for other hazards associated with the commodity are unlikely to be appropriate. Air brushing during the packing process might be expected to remove some mites and quarantine inspection may detect some, although they are small and can be inconspicuous. Consideration of supply chain hygiene will also be required to ensure that contamination does not occur.

12.2 *Amphitetranychus viennensis* – Hawthorn spider mite

Scientific name: *Amphitetranychus viennensis* (Zacher, 1920) (Acarina: Tetranychidae)

Other relevant scientific names: *Tetranychus viennensis* Zacher, 1920; *Tetranychus* (*Amphitetranychus*) *viennensis* Zacher, 1920; *Tetranychus* (*Armenychus*) *viennensis* Zacher, 1920; *Tetranychus* (*Epitetranychus*) *viennensis* Zacher, 1920; *Amphitetranychus crataegi* (Hirst, 1920) ; *Apotetranychus longipenis* Ugarov and Nikolskii, 1937; *Tetranychus crataegi* Hirst, 1920; *Apotetranychus virginis* Ugarov, 1937

Common names: Hawthorn spider mite, sweet cherry spider mite, fruit tree spider mite

12.2.1 Hazard identification

New Zealand status

Amphitetranychus viennensis is not known to be present in New Zealand. Not recorded in: Zhang and others (2002), PPIN (2009).

Biology

Amphitetranychus viennensis is an important pest of Rosaceous fruit crops, such as apple, peach, pear, apricot, plum, hawthorn, cherry, sweet cherry and raspberry, in China, Georgia, Japan, Russia, Turkey, Ukraine and other European countries (CPC, 2007). It feeds on the under surface of the leaf. Multiplication is influenced by the number of stomata on the underside of the leaves, the leaf thickness, and the thickness of spongy mesophyll and palisade parenchyma (Skorupska, 1998).

After mating, adult females overwinter under the bark of trunks and branches (Chepurnaya and Myalova, 1981). Eggs are laid on the lower surface of leaves in spring (Rambier, 1954), and are covered individually with silky thread (Kasap, 2003). In Anhui, China, mites are more common on the upper part of the tree and the inner portion of the canopy in the spring. The population increases in May and June, with potential to cause damage until October. The number of generations per year is variable and ranges from 4–6 in Iran, to 9–10 in Turkey. In Iran, the generation time is 84–106 days, and females lay 36–154 eggs (CPC, 2007).

Development from egg to adult at 22–25°C takes 12–14.5 days, although more rapid development, 9.1 and 8.6 days in female and male individuals, respectively, has also been observed (CPC, 2007).

A. viennensis is highly adaptable to different food plants. It has been demonstrated that it may take only two to three generations to adapt to a new food plant in its known host range (CPC, 2007).

Crawling is the main means of dispersal within a tree and between neighbouring trees. Aerial dispersal by wind over longer distances involves two different launching behaviours: spinning down from the foliage on a thread until the wind breaks the thread; and facing into the wind with the forelegs upright (CPC, 2007).

The most common symptom of *A. viennensis* is leaf-flecking. Continuous feeding may cause yellow spots, with the foliage becoming yellowish-grey (CPC, 2007). Photosynthesis is sensitive to mite damage; a significant decrease in photosynthesis in apple has been recorded when leaf damage reached or exceeded 15% in China (CPC, 2007). Heavy infestation of *A. viennensis* may cause water loss, premature leaf drop, impair fruit formation, and lower the resistance of the host to winter conditions (CPC, 2007). In apple, pear, and peach, a density of approximately 31.7, 32.3, and 19.5 mites per leaf may cause early leaf fall (Li et al, 1998a).

The mite causes a reduction in fruit size and weight, but not in the number of fruit produced, however flower and fruit production in the following year can be reduced. In apple, 100 or more mites per leaf may result in a yield loss of 40–65% (CPC, 2007). *A. viennensis* may cause particular damage in dry years (Chepurnaya and Myalova, 1981).

The economic threshold for applying acaricides to apple is 4–5 individuals per leaf during the first half of the vegetative period, which is more sensitive to mite damage, and 7–8 mites per leaf during the second half of the vegetative period (CPC, 2007).

Hosts

A. viennensis is generally considered a pest of Rosaceae (CPC, 2007), but is also recorded from members of the Apocynaceae, Betulaceae, Caprifoliaceae, Fagaceae, Moraceae, Saxifragaceae and Tiliaceae (Migeon and Dorkeld, 2006).

Within the Rosaceae the following hosts have been recorded: *Amelanchier canadensis*, *Chaenomeles* sp., *Crataegus azarolus*, *C. grandiflora*, *C. monogyna*, *C. oxyacantha*, *Crataegus* sp., *Cydonia oblonga*, *Fragaria* sp., *Malus domestica*, *M. floribunda*, *M. hissarica*, *M. sieboldii*, *Mespilus* sp., *Prunus armeniaca*, *P. avium*, *P. cerasus*, *P. divaricata*, *P. domestica*, *P. dulcis*, *P. insititia*, *P. padus*, *P. persica*, *P. sagdiana*, *P. serotina*, *P. serrulata*, *P. spinosa*, *P. taiwanina*, *P. yedoensis*, *Pyracantha coccinea* (Migeon and Dorkeld, 2006); *Pyrus bretschneideri* (AQSIQ, 2007; Sun and Qiao, 2004); *Pyrus communis* (CPC, 2007; Migeon and Dorkeld, 2006); *Pyrus pyrifolia* (Kishimoto and Adachi, 2006; AQSIQ, 2007); *Pyrus* spp. (Jeppson et al, 1975); *Pyrus japonica*, *Pyrus pollveria*, *Rubus idaeus*, *R. plicatus*, *Sorbus aucuparia*, *S. intermedia* (Migeon and Dorkeld, 2006).

Plant parts affected

Leaves, bark (CPC, 2007; Jeppson et al, 1975); feeds mainly on leaves and on flowers of fruit trees; also feeds on the surface of developing fruit and may foul them with its webbing (CFIA, 2008).

Geographical distribution

Asia: Azerbaijan (CPC, 2007); China (CPC, 2007; Garland, 1995; Li et al, 1998a); Georgia (Republic), Iran, Japan, Korea (DPR), Pakistan, Turkey, Uzbekistan (CPC, 2007). **Europe:** Austria, Bulgaria, Germany, Hungary, Poland, Romania, Russian Federation, Spain, Sweden, Ukraine, United Kingdom (CPC, 2007).

Within China, *Amphitetranychus viennensis* is widespread across the mid-northern region, and is recorded in Anhui, Gansu (CPC, 2007); Hebei (Li et al, 1998a); Henan, Jiangsu, Liaoning, Ningxia, Shandong, Taiwan and Xinjiang (CPC, 2007).

Hazard identification conclusion

Amphitetranychus viennensis is a pest of *Pyrus*, and has been recorded on fruit. It is present in China but not in New Zealand, and is considered to be a potential hazard.

12.2.2 Risk assessment

Entry assessment

Since *Amphitetranychus viennensis* oviposits on the lower surface of leaves (Rambier, 1954), it is assumed that eggs are unlikely to be associated with pear fruit. Nymphs and adults are mobile and more likely to be associated with fruit.

A. viennensis is widespread across many of the main pear producing Provinces of China. It feeds predominantly on leaves but is dispersed either by crawling or on silken threads by the wind. It is assumed that some ballooning mites are likely to land on pear fruit. It is reported that when mite populations are high, the female may overwinter in the calyx crevices or in the depression on the stem-end of mature fruit, like *Tetranychus urticae* (APHIS, 2006). Similarly it is reported that *A. viennensis* does not feed on apples, but is suspected to attach accidentally to apple fruit in autumn as females enter diapause (Lee and Lee, 1997). Since both adults and nymphs are less than a millimetre in size they may not be detected during the harvest and packing process. Mated adult females overwinter in China and it assumed that they would survive refrigerated shipment to New Zealand.

Given that:

- *A. viennensis* is widespread in China;
- it feeds predominantly on leaves; but
- adult females may over-winter in the calyx or stem-end areas of fruit;
- they are very small and may not be detected during the harvest and packing processes;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and often the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. The waste material generated would allow some *A. viennensis* to disperse and find a suitable host. For example, if fruit material infested with *A. viennensis* were disposed in a compost bin, or on the road side near a Rosaceae host plant, the mites could crawl or balloon to the new host. The major hosts of *A. viennensis* include fruit trees which are distributed widely throughout New Zealand, both in commercial orchards and in landscape and backyard plantings. This will increase the likelihood of successful exposure.

Given that:

- adults are mobile;
- suitable hosts are widespread in New Zealand;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

Overwintering mated females are the most likely lifestage to enter on imported pears. This means that males do not need to enter to start a viable population. Multiple generations per year will increase the speed with which a viable population can establish and spread. *A. viennensis* occurs in many parts of temperate Asia and Europe. Whilst the highest reproductive rate, and rate of increase, and shortest generation time of *A. viennensis* has been reported at 35°C (Ji et al, 2005), it is still able to develop at 15°C, albeit more slowly (Gotoh, 1987). It is therefore assumed that the climate in New Zealand will not be a barrier to its establishment. *A. viennensis* is polyphagous and its hosts include fruit trees which are widely distributed in New Zealand. Shortage of host plants is unlikely to limit its establishment and spread. Furthermore it is highly adaptable to different food plants.

Given that:

- gravid females could theoretically establish a population without needing to find a mate;
- the New Zealand eco-climatic conditions are unlikely to be a barrier to establishment;
- there would be no shortage of available hosts;

The likelihood of establishment is considered to be high and therefore non-negligible.

Consequence assessment

Economic consequences

Amphitetranychus viennensis is primarily a pest of pome and stone fruit, and woody ornamental plants (Kasap, 2003), and could impact on several crops grown commercially in New Zealand, for example, apples, pears and stonefruit.

The predatory mite, *Metaseiulus occidentalis*, which is present in New Zealand (Spain and Luxton, 1971), was introduced to China from Australia and the USA in 1980. In Gansu and Xinjiang, *M. occidentalis* has given effective control of *A. viennensis* (Zhang et al, 1986).

Given the sub-optimal temperatures in New Zealand, the presence of one of its biological controls, and the presence of *Panonychus ulmi*, with which it competes for food sources, this mite may have a lesser impact in New Zealand than it does overseas.

The potential economic consequences are considered to be low to moderate.

Environmental consequences

Although *A. viennensis* has been recorded on plant hosts in several families, the major hosts are members of the Rosaceae. There are no New Zealand native members of the primary host genera (*Malus*, *Pyrus* and *Prunus*); however, there may be some effect on New Zealand Rosaceae such as *Acaena*, *Geum*, *Potentilla* and *Rubus* species. Beever et al. (2007) suggested that, in terms of risk to native flora, spider mites are a high risk group, particularly polyphagous species (based on known attacks on native plants by exotic species present in New Zealand).

The potential environmental consequences are considered to be low to moderate.

Human health consequences

There are no known human health consequences.

Risk estimation

Amphitetranychus viennensis has a low likelihood of entry, moderate likelihood of exposure and high likelihood of establishment in New Zealand. The potential impact within New Zealand is low-moderate. *As a result the risk estimate for A. viennensis is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

12.2.3 Assessment of uncertainty

There is uncertainty over the association of *A. viennensis* with fruit.

12.2.4 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

A. viennensis is widespread throughout the main pear growing areas of China and pest-free areas are not likely to be a viable option.

Bagging of fruit

There is no evidence that bagging excludes this mite.

Cold treatment/shipping (in transit)

The most favourable temperature for *A. viennensis* is 35°C and it is known to have a high overwintering mortality. Non-diapausing mites are likely to be killed by temperatures of 0–1°C. However since mated females are the over-wintering lifestage it is likely that they would survive.

In-field management

Numerous acaricides have been recommended to control *A. viennensis*; however, resistance to acaricides has also been reported. Application of acaricide is recommended in the spring when the females are active; or in the pink-bud stage; or when the density of *A. viennensis* reaches an action threshold (CPC, 2007).

Miticides registered for the control of European red mite (*Panonychus ulmi*) on pipfruit in New Zealand (New Zealand Agrichemical Manual, 2004) have been shown to be effective on A. *viennensis*. Examples are: abamectin, clofentezine, azocyclotin, and fenpyroximate (Zhou et al, 2005).

In-field control of *A. viennensis* in China may be an option (for example, a specified regime) if efficacy can be demonstrated.

Phytosanitary inspection prior to export

Adult females are dark-red and diapausing individuals are bright red, approximately 0.5–0.6 mm in length. These mites may be detected by inspection.

Air brushing

There is no specific evidence on the efficacy of air brushing during the packing the process in removing mites. Nonetheless, it might be expected to remove at least some.

Ethyl formate fumigation

Ethyl formate is a naturally occurring component in fruit with insecticidal properties, that has been used as a fumigant for stored products. Eggs and adults of the Pacific spider mite, *Tetranycus pacificus* had an LD_{99} of 1.9 % and 3.7 % respectively, at one hour treatment. Bartlett pears tested for one hour at room temperature had a maximum tolerance dose of 3.2 %. Doses in excess of this caused skin browning (Mitcham, 2005). Experiments to determine the lethal concentration for *Tetranychus urticus* on oranges found that much higher concentrations were required for eggs than for adults. The dose depends on the sorptive properties of the fruit being fumigated, as well as application methods including application of CO_2 (Sung et al, 2008). The effective dose for treatment against these mites is not known, but it is an option that warrants further investigation.

12.3 *Tetranychus kanzawai – kanzawa spider mite*

Scientific name: *Tetranychus kanzawai* Kishida, 1927 (Acarina: Tetranychidae)
Other relevant scientific names: *Tetranychus hydrangeae* Pritchard and Baker
Common name: kanzawa spider mite

12.3.1 Hazard identification

New Zealand status

Tetranychus kanzawai is not known to be present in New Zealand. Not recorded in: Manson (1987), Migeon and Dorkeld (2006), PPIN (accessed 22/10/2009).

Biology

T. kanzawai is one of the most common spider mites in the East Asian region (Takafuji and Hinomoto, 2008) and is a serious pest of various crops including tea, fruit trees and vegetables (Takafuji et al, 2001). It has become an important pest of pears in China since the 1990s (Jun and Gao, 2002). *Tetranychus* mites usually feed on the under-surface of leaves (Jepson *et al*, 1975).

The life history traits vary depending on the host. Table 1 provides the results of laboratory studies on leaf discs of *Pyrus pyrifolia* (Gotoh and Gomi, 2003). Approximately 84 eggs were laid per female, of which 85% were female. Adult longevity was about 21 days (Gotoh and Gomi, 2003). Similar results were reported by Kondo and Takafuji (1985). The mean average life span of adult females deprived of food and water was about 2.4 days (Kondo and Takafuji, 1985). Two of the life stages are quiescent (protocrysalis and deutonymph). These stages are anchored to the substrate (Ikegami *et al,* 2000).

Table 1. Approximate development time in days at 25°C on Japanese pear (Gotoh and Gomi, 2003)

Sex	Number tested	Egg	Larva	Protochrysalis	Protonymph	Deutochrysalis	Deutonymph	Teleiochrysalis	Total
F	36	4.8	1.1	0.8	1.0	0.9	1.0	1.2	10.8
M	23	4.9	1.1	0.6	0.8	0.3	1.0	1.0	9.7

Unfertilised eggs develop into males, while fertilised eggs develop into females (Shih, 1979). The proportion of females in a population averages between 0.76 and 0.83. The sex ratio is determined by the genotype and age of the mother: no females are produced from mothers more than 14 days old (Takafuji and Ishii, 1989; Shih, 1979).

Females tend to oviposit in a localised area of the leaf, with most of the eggs produced during a peak period of a few days after a preoviposition period (Shih, 1979). Studies on strawberries in China showed that eggs and active stages are aggregated (Zhang et al, 1996). The incidence of plant infestation may be as high as 90–100%, with the number of mites on each leaf reaching 2000–3000 (Zhang et al, 1996).

T. kanzawai constructs complicated webs over the surface of a leaf and usually lives under these (Oku, 2008). The webs appear to fulfil a number of functions including providing a refuge from predation and from adverse weather (Oku *et al,* 2003).

T. kanzawai feeding on leaves, causes the leaves to become brown, wither and eventually fall from the tree. Population levels depend in part on the extent of deterioration in the condition of the host. *T. kanzawai* disperses rapidly from leaves which have deteriorated due to feeding (Kondo and Takafuji, 1985). *T. kanzawai* reaches potential host plants either by random walking or passive wind dispersal (Oku et al, 2003). It is highly polyphagous and utilises various host plants (including wild plants) as they are available and suitable as food in different seasons (Kondo and Takafuji, 1985). The seasonal pattern of *T. kanzawai* abundance in pear orchards reportedly varies greatly, depending on amongst other things the pest control regime, abundance of natural enemies (Kawashima et al, 2006) and availability of alternative hosts. Populations may peak in summer (Kawashima et al, 2006) and in some cases in the Autumn (Kishimoto, 2002). Densities reportedly vary from 0.1 mite per leaf to 4 mites per pear leaf (Kawashima et al, 2006).

T. kanzawai enters a reproductive diapause in response to short days and low temperatures in Autumn, and over-winters as a diapausing adult female (Takafuji *et al*, 2001). Kadono (1998) indicates that over-wintering females congregate at the calyx end of pear fruit. In Japan, populations of *T. kanzawai* had a strong diapause capacity on all host species. They expressed more than 90% diapause at 15°C in the four main islands of Japan, whereas the populations on the Okinawa islands further south exhibited a very low incidence or no diapause. Diapause capacity was greater in populations from deciduous hosts (Takafuji *et al*, 2001).

Hosts

160 hosts in 62 families are known (Migeon and Dorkeld, 2006). Major hosts are *Arachis hypogaea* (groundnut), *Camellia sinensis* (tea), *Carica papaya* (papaw), *Citrus, Fragaria ananassa* (strawberry), *Glycine max* (soyabean), *Humulus lupulus* (hop), *Malus domestica* (apple), *Morus alba* (mora), *Prunus avium* (sweet cherry), *Prunus persica* (peach), *Pyrus communis* (European pear), *Pyrus pyrifolia*, *Solanum melongena* (aubergine), *Vitis vinifera* (grapevine) (Migeon and Dorkeld, 2006; CPC, 2007).

There are indications that host races differ genetically and four possible types have been identified. The population associated with pears is also that associated with hydrangea (Gomi and Gotoh, 1996).

Plant parts affected

Although primarily associated with leaves, *T. kanzawai* also occurs on fruit of *Pyrus pyrifolia* (Kadono, 1998). Soma et al. (2002) report the results of phosphine fumigation trials for *T. kanzawai* and *Pyrus pyrifolia.* The trials were undertaken because of problems with exporting pears from Japan to the USA and Canada due to the mite.

Geographic distribution

Africa, Australia, USA, China, India, Malaysia, Japan, Thailand, Taiwan, Vietnam, Korea, Greece (Migeon and Dorkeld, 2006; Takafuji and Hinomoto, 2008).

In China it has been recorded from Anhui, Fujian, Hong Kong, Jiangsu, Jianxi, Jilin, Liaioning, Shaanxi, Shandong, Zheijiang (CPC, 2009).

Hazard identification conclusion

Tetranychus kanzawai has been recorded on *Pyrus* spp., and is associated with pear fruit. It is present in China and is not known to be present in New Zealand. Therefore, *T. kanzawai* is considered to be a potential hazard.

12.3.2 Risk assessment

Entry assessment

The prevalence of *T. kanzawai* in pear orchards will depend on the population dynamics at the location as well as the availability of alternative hosts. The association with pear fruit will depend on these dynamics in relation to harvest time. No reports have been found of *T. kanzawai* feeding or laying eggs on pear fruit. However females have been reported over-wintering at the apex of pear fruit. Adults disperse when the quality of the leaf on which they are feeding deteriorates. This is most likely to be when densities are highest, and populations have been reported to peak in the Autumn. Dispersal is passive and it is likely that dispersing adults would land on nearby fruit.

All life stages are very small with adults measuring less than 1mm (CPC, 2009). They are not likely to be detected during the standard harvest and packing processes. Mites are regularly intercepted on pears at the border in New Zealand (Section 3.2).

Adult females over-winter and can enter a state of diapause. Whilst they're survival is very low when deprived of food and water in laboratory situations, it is assumed that they would be likely to survive transfer to New Zealand in a state of diapause.

Given that:

- *T. kanzawai* is a pest of pears;
- Adults are most likely to be associated with leaves, although at harvest time, they may be associated with fruit;
- The mites are very small and many not be detected during the standard harvest and packing processes;
- survival in the absence of leaf material is uncertain but likely to be possible in a state of diapause,

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Fresh imported *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and the skin, but dispose of the seeds and core, but whole fruit or parts of the fruit are sometimes discarded. Such material could allow *T. kanzawai* associated with the fruit to disperse and find a suitable host.

T. kanzawai is polyphagous. Major hosts are citrus, strawberry, peach, grapevine, vegetables such as beans and wild plants such as clover, in addition to pears. Suitable hosts are likely to be available near disposal sites. Dispersal is by active walking or passively by wind.

Given that:

- adults are mobile;
- suitable hosts are widespread in New Zealand;

The likelihood of exposure considered to be moderate and therefore non-negligible.

Establishment assessment

Females are the most likely sex to enter on imported fruit. *T. kanzawai* has a reproductive biology whereby unfertilised eggs develop into males and fertilised eggs develop into females. However, unfertilised females may mate with their male offspring, enabling a population to be founded by a single female. This would only occur if the female does not disperse and stays alive long enough for the male offspring to develop to adulthood and locate the female. The optimal temperature for *T. kanzawai* is between 25°C and 30°C.The temperature in most parts of New Zealand will be less than optimal. The likelihood of survival of one female long enough for its male offspring to survive and locate the female to mate is considered extremely low. Eggs and active stages are aggregated, which will increase the likelihood of adults finding a mate of the opposite sex.

Spider mites are wingless and migrate long distances by passive means The optimal developmental temperature for *T. kanzawai* is between 25°C and 30°C (HuaGuo et al, 1998). The developmental threshold temperatures for eggs is about 14°C. This suggests the temperature in most parts of New Zealand will be less than optimal. The most suitable regions are likely to be in the northern, warmer parts of New Zealand and perhaps central Otago.

Given that:

- a single female can found a population;
- *T. kanzawai* can spread long distances through passive dispersal;
- *T. kanzawai* is polyphagous, and acceptable hosts are widely available but
- only the warmer northern regions are likely to have a suitable climate for *T. kanzawai*;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

On strawberries in China, the incidence of plant infestation may be as high as 90–100%, with the number of mites on each leaf reaching 2000–3000. The mite can infest a number of important crops, such as citrus, *Prunus* and *Pyrus* spp., as well as grapes. Besides direct costs of losses due to defoliation and reduced productivity and extra control measures needed, establishment could also affect market access. Given the wide host range, home gardeners are also likely to be affected. The scale of impacts is likely to be limited by the restricted distribution of the mite in New Zealand.

The potential economic consequences are considered to be moderate and therefore non-negligible.

Environmental consequences

T. kanzawai has hosts in many families, including Rosaceae and Fabaceae (Migeon and Dorkeld, 2006); both these families have many native representatives in New Zealand. For Rosaceae, this includes *Rubus* (for example, bush lawyer, *R. cissoides*), and *Acaena* (for example *A. anserinifolia*, bidibidi), as well as *Potentilla* and *Geum* which are less commonly encountered. For Fabaceae, this includes *Carmichaelia* spp. (native brooms), *Clianthus puniceus* (kakabeak), *Monitigena novae-zelandiae* and, most commonly, *Sophora* spp. (kowhai). Based on known attacks on native plants by exotic species present in New Zealand, Beever et al. (2007) suggest that in terms of risk to native flora, spider mites are a high risk group, particularly polyphagous species. However, polyphagous species that are highly damaging in natural environments appear to be exceptional.

The potential environmental consequences are considered to be low to moderate and therefore non-negligible.

Human health consequences

There are no known human health consequences directly related to *T. kanzawai*, although, spider mites can cause allergic symptoms in laboratory workers who study them. Although mites are reported to cause respiratory allergy, the mites responsible belong to completely different mite families.

Risk estimation

The likelihood of entry is considered to be low, the likelihood of exposure is considered to be moderate, and the likelihood of establishment is considered to be low. The potential economic consequences are considered to be moderate and the environmental consequences low to moderate. *As a result the risk estimate for Tetranychus kanzawai is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

The degree to which *T. kanzawai* occurs on pear fruit at the time of harvest and their ability to survive on fruit is unclear.

12.3.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

The current distribution of *T. kanzawai* in China is not well known. However, pest free area status may be an option for pears grown in some provinces if the status can be verified in accordance with the requirements of ISPM 4 or ISPM 10.

Bagging of fruit

Due to the small size of the mites, bagging is not expected to fully restrict the access to the fruit. Therefore bagging is not considered an effective option.

Cold treatment

The optimum temperature for development of *T. kanzawai* is between 25°C and 30°C. Non-diapausing mites would be expected to be killed by prolonged temperatures of 0-1°C. However, the influence of diapause on survival is unknown. It is unlikely to be an effective option.

Air brushing

There is no specific evidence on the efficacy of air brushing in removing mites during the packing process. Nonetheless, it is expected to remove at least some.

Pre-export phytosanitary inspection

The mites are not readily detected because of their very small size.

A combination of air brushing and phytosanitary inspection is expected to manage the risk to a greater degree than either measure in isolation.

12.4 *Tetranychus truncatus* – *cassava mite*

Scientific name: *Tetranychus truncatus* Ehara, 1956 (Acarina: Tetranychidae)
Other relevant scientific names: *Eotetranychus truncatus* Estebanes and Baker, 1968
Common names: cassava mite, spider mite, truncated mite

12.4.1 Hazard identification

New Zealand status

Tetranychus truncatus is not known to be present in New Zealand. Not recorded in: Ramsay (1980), Zhang and others (2002), Manson (1987).

Biology

Tetranychus truncatus causes spotting and yellowing of leaves of cotton and maize (CPC, 2007). It is an important pest of maize in northern China, and a reduction in yield of 15% was reported from Hebei Province. In Beijing, it can damage up to 70% of the leaves of *Sophora japonica* (Chinese scholartree) in urban areas and 90% of the leaves in suburban areas (CPC, 2007). It is a common pest of upland vegetable crops including beans (Chao and Lo, 1974). It is a pest of mulberry and other plants in Japan and the Philippines (Jeppson et al, 1975).

In China, *T. truncatus* overwinters in adult form, mainly in cracks in stems and branches of *Sophora japonica*, with fewer numbers on branchlets, weeds and root soil layers (Chen et al, 1996). There are 15–17 generations per year with an average generation lasting for 6.7 days at 28°C. The lifespan is 7.5 days for males and 10.7 days for females at 27°C (CPC, 2007).

On *Ziziphus sativa* (jujube), it has been observed to overwinter as eggs in gaps in the bark (Li et al, 1998b). In spring, the eggs hatch and young mites move to grasses. When the young leaves of the jujube trees open, the mites move up the trunk of the tree and attack the leaves (CPC, 2007).

On maize, overwintering adult females become active and start to lay eggs from late March to early April. They move to spring-sown maize fields from the end of May to early June, and to summer-sown maize fields from late June to early July (CPC, 2007).

In Taiwan, each female laid an average of 60 eggs in about 9 days (Chao and Lo, 1974).

In a study on the effects of temperature on the development of *T. truncatus*, the shortest generation time was 5.31 days at 32.2°C. Higher temperatures resulted in a longer generation time. These results are supported by reports of heavy infestations in the field in seasons with high temperature and low precipitation (Fan et al, 2000).

The developmental zero temperature of *T. truncatus* has been found to be 14.86°C and the thermal summation is 48.84 day-degrees (Lu et al, 2002).

There have been many studies on the effect of temperature on the development of *T. truncatus*. Although they do not all agree, the overall results suggest that it can develop and reproduce within a wide range of temperatures. Sakunwarin and others (2003) suggest that the range 24–31°C is the most suitable for the development, survival rate and reproduction of *T. truncatus*.

Hosts

Polyphagous, particularly on herbaceous crops and shrubs. Hosts have been reported in the Apiaceae, Arecaceae, Cucurbitaceae, Fabaceae, Euphorbiaceae, Malvaceae, Moraceae, Poaceae, Rhamnaceae, Rosaceae, Solanaceae (CPC, 2007). In the Rosaceae, *Prunus* sp. (Migeon and Dorkeld, 2006); *Pyrus pyrifolia* (Migeon and Dorkeld, 2006; Bolland et al, 1998); *Pyrus bretschneideri* (MAFBNZ, 2009); *Rosa hybrida* (Migeon and Dorkeld, 2006).

Plant parts affected

Fruit (MAFBNZ, 2009); leaves (CPC, 2007). Even though these mites do not feed on apples, they are suspected to attach accidentally to apple fruit in autumn as females enter diapause (Lee and Lee, 1997).

Geographical distribution

Asia: China (CPC, 2007; Bolland et al, 1998); Japan, Korea (Republic of), Malaysia, Philippines (CPC, 2007); Taiwan (Chao and Lo, 1974); Thailand (CPC, 2007).
Oceania: Guam (CPC, 2007).

Within China, *T. truncatus* is widespread and is recorded in Anhui, Fujian, Gansu, Guangdong, Guangxi, Hainan, Hebei, Henan, Hubei, Jiangsu, Jiangxi, Ningxia, Shaanxi, Shandong, Sichuan, Zhejiang (CPC, 2007).

Hazard identification conclusion

Tetranychus truncatus is recorded on *Pyrus*, and has been associated with fruit. It is present in China. It is not present in New Zealand, and is considered to be a potential hazard.

12.4.2 Risk assessment

Entry assessment

There is little information on the sites of oviposition, but *T. truncatus* has been observed to overwinter as eggs and adult females in gaps in bark. Eggs are unlikely to be associated with pear fruit.

Tetranychus truncatus is widespread across some of the main pear producing provinces of China, although it does not appear to be a pest of pears. It is a pest of many plant families, feeding predominantly on the leaves. *Pyrus* is not acknowledged as a major host (CPC, 2007). Lee and Lee (1997) indicate that the mites do not feed on apples, but are suspected to attach accidentally to apple fruit in autumn as females enter diapause, and hibernate in the calyx area.

Mated adult females overwinter in China and it assumed that they would survive shipment to New Zealand. Adult *T. truncatus* has been intercepted at the New Zealand border on *Pyrus bretschneideri* from China (December, 2000) (MAFBNZ, 2009).

Given that:

- *T. truncatus* is widespread in China;
- *Pyrus* spp. are not major hosts;
- adult females may hibernate in the calyx area of fruit;
- they are very small and may not be detected during the harvest and packing processes;
- adult *T. truncatus* has been intercepted at the New Zealand border on pears from China;

The likelihood of entry is considered to be low and therefore non-negligible.

Exposure assessment

Fresh *Pyrus* fruit is likely to be distributed throughout New Zealand's city centres as well as provincial regions. Generally, people consume the flesh and often the skin, but dispose of the seeds and core. However, whole fruit or parts of the fruit are not always consumed. The waste material generated would allow some *T. truncatus* to disperse and find a suitable host. For example, if fruit material infested with *T. truncatus* were disposed in a compost bin, or on the road side near a host plant, the mites could crawl or balloon to the new host. *Tetranychus truncatus* is polyphagous, particularly on herbaceous crops and shrubs. It is relatively mobile. Suitable hosts are likely to be widespread in New Zealand.

Given that:

- adults are mobile;
- suitable hosts are widespread in New Zealand;

The likelihood of exposure is considered to be moderate and therefore non-negligible.

Establishment assessment

- Diapausing females are the mostly likely stage to enter New Zealand on this pathway. Like *A. viennensis*, *T. truncatus* is likely to overwinter as mated females, and it is unlikely that males and females would need to enter together to start a viable population. Multiple eggs will also increase the likelihood of establishing a viable population.

The developmental zero (base temperature for development) of *T. truncatus* is 14.8°C, and the range 24–31°C is most suitable for the development, survival and reproduction. It is likely that the climate in New Zealand would be sub-optimal for the establishment of this mite, which has not yet been found outside of Asia, however, it may be able to establish in the Far North.

Given that;

- gravid females producing multiple eggs could theoretically establish a population without needing to find a mate;
- the climate of New Zealand is likely to be sub-optimal over most of its extent;

The likelihood of establishment is considered to be low and therefore non-negligible.

Consequence assessment

Economic consequences

Tetranychus truncatus is a polyphagous pest which may have some impact on several crops grown commercially in New Zealand, for example, beans and maize.

The predatory mite, *Amblyseius* (*Neoseiulus*) *longispinosus*, is present in New Zealand (PPIN, 2008) and feeds on *T. truncatus*. Several studies have looked at using this mite as a biological control of *T. truncatus*.

Given the sub-optimal temperatures in New Zealand, the presence of one of its biological controls, and its current restricted distribution, this mite may have a lesser impact in New Zealand than it does in China.

Much of the literature relates to damage caused by ‘spider mites’ (*T. truncatus* in combination with other species) making it difficult to assess its importance.

The potential economic consequences are considered to be low.

Environmental consequences

Tetranychus truncatus has been recorded on plant hosts in many families. There are New Zealand native members of many of the recorded families, for example Apiaceae, Arecaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Malvaceae, Moraceae, Poaceae, Rosaceae and Solanaceae. Several New Zealand genera are recorded as hosts (*Potentilla* sp. and *Solanum* sp.). Beever et al. (2007) suggested that, in terms of risk to native flora, spider mites are a high risk group, particularly polyphagous species (based on known attacks on native plants by exotic species present in New Zealand).
The potential environmental consequences are considered to be moderate

Human health consequences

There are no known human health consequences.

Risk estimation

Tetranychus truncatus has a low likelihood of entry, moderate likelihood of exposure and low likelihood of establishment in New Zealand. The potential impact within New Zealand is low. *As a result the risk estimate for T. truncatus is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

Assessment of uncertainty

There are gaps in the available information on the lifecycle of this mite.

12.4.3 Risk management

Options

A subset of the risk management options identified in Chapter 4 that are relevant to this organism is listed below. Their effect in managing the risk posed by this organism is assessed.

Pest free area

T. truncatus is widespread in the main pear growing areas of China and pest-free areas are not likely to be a viable option.

Bagging of fruit

There is no evidence that bagging excludes this mite.

Cold treatment/shipping (in transit)

One study found that the most favourable temperature for *T. truncatus* development was 32.2°C. Non-diapausing mites are likely to be killed by temperatures of 0–1°C. However since mated females are the over-wintering lifestage it is likely that they would survive.

In-field management

Numerous acaricides have been recommended to control *T. truncatus* (CPC, 2007); however, resistance to acaricides has also been reported. In addition, cultural methods, such as scraping the old bark in the early spring or sticking a viscous glue ring on the trunk of the tree have also been suggested (Li et al, 1998b). Ma and others (2005) found that eradicating weeds at cotton field edges reduced the damage caused by cotton spider mites. The efficacy of these measures is not known.

Air brushing

There is no specific evidence on the efficacy of air brushing during the packing the process in removing mites. Nonetheless, it might be expected to remove at least some.

Phytosanitary inspection prior to export

Adult females are dark-red and approximately 0.5 mm in length. These mites may be detected by inspection.

Ethyl formate fumigation

Ethyl formate is a naturally occurring component in fruit with insecticidal properties, that has been used as a fumigant for stored products. Eggs and adults of the Pacific spider mite, *Tetranycus pacificus* had an LD_{99} of 1.9 % and 3.7 % respectively, at one hour treatment. Bartlett pears tested for one hour at room temperature had a maximum tolerance dose 3.2%. Doses in excess of this caused skin browning (Mitcham, 2005). Experiments to determine the lethal concentration for *Tetranychus urticus* on oranges found that much higher concentrations were required for eggs than for adults. The dose depends on the sorptive properties of the fruit being fumigated, as well as application methods including application of CO_2 (Sung et al, 2008). The effective dose for treatment against *T. truncatus* is not known, but it is an option that warrants further investigation.

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Appendix 1. Hazard identification for Pyrus fresh fruit from China

The hazard identification process identified organisms associated with *Pyrus* plants. Organisms were considered further (classed as a potential hazard) if they were present in China, found on fruit and were not known to be present in New Zealand. Organisms were also classed as potential hazards if they are present in New Zealand, but are vectors of pathogens or parasites that are not present in New Zealand; if the organisms have strains that do not occur in New Zealand; if the organism is of restricted distribution in New Zealand; if the organism is under official control in New Zealand; or if the organism is listed on the unwanted organisms register (UOR) as a notifiable organism.

*Organisms which were excluded from further consideration. See Appendix 2 for explanation.

Scientific name	Common name	Associated with *Pyrus* spp. (ref)	Plant part association (all hosts)	Likely to be present on *Pyrus* fruit	Present in China	Present in New Zealand	Potential hazard*
BACTERIA							
Erwinia carotovora subsp. *carotovora* (Jones, 1901) Bergey et al, 1923 (Enterobacteriaceae)	bacterial root rot of sweet potato	CPC, 2007; Bradbury, 1986	soft rot (Bradbury, 1986); bulbs, leaves, roots, stems, fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (Zhang and Huang, 1990; Hseu et al, 2001)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Erwinia chrysanthemi Burkholder et al, 1953 (Enterobacteriaceae)	bacterial wilt of dahlia	CPC, 2007	roots, stems, leaves, fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; Zhao et al, 2000)	yes (Pennycook, 1989; Young, 2000)	no
Erwinia herbicola (Lohnis, 1911) Dye, 1964 (Enterobacteriaceae)	bacterial grapevine blight	CPC, 2007; Landcare NZFUNGI, 2007	roots, leaves (Bradbury, 1986)	no	yes (CPC, 2007; Zhang et al, 1999a)	yes (Landcare NZFUNGI database, 2008; Young, 2000)	no
Pseudomonas cichorii (Swingle, 1925) Stapp, 1928 (Pseudomonadales: Pseudomonadaceae)	bacterial blight of endive	CPC, 2007; Bradbury, 1986	leaves, stems (Bradbury, 1986); fruit (CPC, 2007)	yes (nectarines (CPC, 2007))	yes (CPC, 2007; CAB International, 2006a)	yes (Landcare NZFUNGI database, 2008; Pennycook, 1989; Young, 2000)	no
Pseudomonas fluorescens Migula, 1895 (Pseudomonadales: Pseudomonadaceae)	pink eye: potato	CPC, 2007	leaves (CPC, 2007)	no	yes (CPC, 2007)	yes (Landcare NZFUNGI database, 2008; Young, 2000)	no

Scientific name	Common name	Associated with *Pyrus* spp. (ref)	Plant part association (all hosts)	Likely to be present on *Pyrus* fruit	Present in China	Present in New Zealand	Potential hazard*
Pseudomonas marginalis (Brown, 1918) Stevens, 1925 (Pseudomonadales: Pseudomonadaceae)	kansas lettuce disease	CPC, 2007	leaves, occasionally a rot in storage (Bradbury, 1986)	yes (all hosts (Bradbury, 1986))	yes (Zhang et al, 1999a; Hu et al, 1998)	yes (Landcare NZFUNGI database, 2008; Pennycook, 1989; Young, 2000)	no
Pseudomonas putida (Trevisan 1889) Migula, 1895 (Pseudomonadales: Pseudomonadaceae)	biocontrol: *Erwinia* spp.	CPC, 2007; Landcare NZFUNGI, 2007	rhizosphere (Bradbury, 1986)	no	yes (CPC, 2007; Zou et al, 2000)	yes (Lloyd-Jones et al, 1999; Landcare NZFUNGI database, 2008; Young, 2000)	no
Pseudomonas syringae pv. *syringae* van Hall, 1902 (Pseudomonadales: Pseudomonadaceae)	bacterial canker or blast of stone and pome fruit	Bradbury, 1986; Pennycook, 1989	branch, shoot, flower, leaf, fruit (PPIN, 2008); branches, spurs, leaves, fruit (Jones and Aldwinckle, 1990)	yes (CPC, 2007)	yes (CPC, 2007; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Pseudomonas viridiflava (Burkholder, 1930) Dowson, 1939 (Pseudomonadales: Pseudomonadaceae)	bacterial leaf blight of tomato (USA)	CPC, 2007; Bradbury, 1986	leaves, stems, fruit, roots (Bradbury, 1986; CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; CAB International, 2004)	yes (Landcare NZFUNGI database, 2008; Pennycook, 1989; Young, 2000)	no
Rhizobium radiobacter (Beijerinck and van Delden, 1902) Young et al, 2001 (Rhizobiaceae)	crown gall	Bradbury, 1986; Pennycook, 1989	crown, roots, trunk, branches (Jones and Aldwinckle, 1990); roots, trunk at soil line (Bradbury, 1986)	no	yes (CPC, 2007; Biosecurity Australia, 2005)	yes (Landcare NZFUNGI database, 2008; Pennycook, 1989; Young, 2000)	no
Rhizobium rhizogenes (Riker et al, 1930) Young et al, 2001 (Rhizobiaceae)	gall	CPC, 2007; Bradbury, 1986	roots (Hayward and Waterston, 1965); roots (Jones and Aldwinckle, 1990; Hayward and Waterston, 1965); roots, lower stem/trunk (Bradbury, 1986)	no	yes (CPC, 2007; Biosecurity Australia, 2005)	yes (Landcare NZFUNGI database, 2008; Young, 2000)	no
Xanthomonas arboricola pv. *juglandis* (Pierce, 1901) Vauterin (Pseudomonadales: Pseudomonadaceae)	-	Zambujo, 2002	fruit - walnut (CPC, 2007; Arquero et al, 2006)	yes (walnut (CPC, 2007))	yes (CPC, 2007; CAB International, 2001d)	yes (Loreti et al, 2001; McNeil et al, 2001)	no

Scientific name	Common name	Associated with *Pyrus* spp. (ref)	Plant part association (all hosts)	Likely to be present on *Pyrus* fruit	Present in China	Present in New Zealand	Potential hazard*
FUNGI							
Alternaria alternata (Fr.) Keissl., 1912 (mitosporic fungi)	Japanese pear black spot, fruit rot	Farr et al, 1989; Kaneko et al, 2000	bud, fruit, leaf, flower, stem (PPIN, 2008); fruit (Jones and Aldwinckle, 1990; Li and Bi, 2006)	yes (Jones and Aldwinckle, 1990; Li and Bi, 2006)	yes (Zhuang, 2005; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; Falloon, 1985)	no
Alternaria gaisen Nagano, 1920 (mitosporic fungi)	black spot of Japanese pear	Zhang and Huang, 1990; Sheng et al, 2004	petioles, leaves, shoots, fruit (Jones and Aldwinckle, 1990); fruit, leaves (David, 2002); fruit, shoots (Simmons, 1993)	yes (Jones and Aldwinckle, 1990; Tanaka, 1933)	yes (CAB International, 2001a; Zhuang, 2005)	no (not recorded in: Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	yes
Alternaria mali Roberts, 1914 (mitosporic fungi)	alternaria blotch	Farr et al, 1989; Shaw, 1973	fruit (English, 1940); leaves (Shin et al, 2001)	yes (English, 1940)	yes (Zhuang, 2005; Zhang and Huang, 1990)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no*
Alternaria malorum (Ruehle) Braun, Crous and Dugan, 2003 (mitosporic fungi)	-	Gorini and Mori, 1976	storage disease (Gorini and Mori, 1976)	yes (Gorini and Mori, 1976)	yes (Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; PPIN, 2008; Braun and Hill, 2004)	no
Alternaria tenuissima (Kunze) Wiltshire, 1933 (mitosporic fungi)	-	Farr et al, 2007; Geweely and Nawar, 2006	fruit (Geweely and Nawar, 2006); leaves, fruit (Raja et al, 2006)	yes (Geweely and Nawar, 2006)	yes (Zhuang, 2005; Luan et al, 2007)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	no
Alternaria ventricosa R.G. Roberts, 2007 (mitosporic fungi)	-	Farr et al, 2007; Roberts, 2007	fruit stem (Roberts, 2007)	yes (Roberts, 2007)	yes (Farr et al, 2007; Roberts, 2007)	no (not recorded in: Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	yes
Alternaria yaliinficiens R.G. Roberts, 2005 (mitosporic fungi)	chocolate spot of Ya pear	Farr et al, 2007; Roberts, 2005	fruit (Roberts, 2005)	yes (Roberts, 2005)	yes (Farr et al, 2007; Roberts, 2005)	no (not recorded in: Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	yes
Armillaria mellea (Vahl.) Kumm., 1871 (Basidiomycota: Basidiomycetes: Agaricales: Tricholomataceae)	armillaria root rot	Farr et al, 1989; CPC, 2007	roots (Jones and Aldwinckle, 1990); base of trunks, root rot (Teng, 1996); rotten wood (Zhuang, 2005)	no	yes (Zhuang, 2005; Teng, 1996; Bau et al, 2007)	no (not recorded in: Landcare NZFUNGI, 2007; Pennycook, 1989)	no

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Armillaria tabescens (Scop.) Emel, 1921 (Basidiomycota: Basidiomycetes: Agaricales: Tricholomataceae)	armillaria root rot	CPC, 2007; Farr et al, 1989	roots (Farr et al, 1989); roots, wood (Farr et al, 2007)	no	yes (Bau et al, 2007; Zhuang, 2005)	no (not recorded in: Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Ascochyta piricola Sacc., 1875 (mitosporic fungi)	-	Farr et al, 2007; CPC, 2007	leaves (Stadelmann and Schwinn, 1982)	no	yes (Farr et al, 2007; Zhuang, 2005)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Ascochyta prunicola Chi, 1966 (mitosporic fungi)	-	Farr et al, 2007; Tai, 1979	leaves (Indexfungorum, 2008)	no	yes (Farr et al, 2007; Tai, 1979)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Aspergillus candidus Link, 1809 (mitosporic fungi)	-	CPC, 2007	predominantly on stored grains and seeds (Farr et al, 2007); soil, grain, mouldy medicinal materials, food, eyes of human (Zhuang, 2005)	no	yes (Farr et al, 2008; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Aspergillus clavatus Desm., 1834 (mitosporic fungi)	-	CPC, 2007	fruit rot (Hashem, 1996); isolated from soil (Zhuang, 2005)	yes (Hashem, 1996)	yes (Zhuang, 2005; Tai, 1979)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Aspergillus flavus Link, 1809 (mitosporic fungi)	-	Farr et al, 2007; Farr et al, 1989	storage rot (Farr et al, 1989; Farr et al, 2007)	yes (Farr et al, 2007; Farr et al, 1989)	yes (CPC, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Aspergillus niger Tiegham, 1867 (mitosporic fungi)	-	Tai, 1979; Farr et al, 1989	fruit (Sumbali and Mehrotra, 1981; CPC, 2007)	yes (peach (Sumbali and Mehrotra, 1981), all hosts (CPC, 2007))	yes (Zhuang, 2005; CPC, 2007)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Athelia rolfsii (anamorph *Sclerotium rolfsii*) (Curzi) Tu and Kimbr., 1978 (Basidiomycota: Basidiomycetes: Stereales: Atheliaceae)	collar rot	Farr et al, 2007; Pennycook, 1989	fruit (Sumbali and Mehrotra, 1981)	yes (Sumbali and Mehrotra, 1981)	yes (Teng, 1996; CPC, 2007)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Aureobasidium pullulans var. *pullulans* (de Bary) Arnaud, 1918 (mitosporic fungi)	seed rot	Farr et al, 1989; Bazzi et al, 2002	fruit (Bazzi et al, 2002)	yes (Bazzi et al, 2002)	yes (Tai, 1979; Chi et al, 2007)	yes (Landcare NZFUNGI, 2007; PPIN, 2008)	no
Bionectria ochroleuca (anamorph *Clonostachys rosea*) (Schwein.) Schroers and Samuels, 1997 (Ascomycota: Ascomycetes: Hypocreales: Bionectriaceae)	-	Sumbali and Mehrotra, 1981	fruit (Sumbali and Mehrotra, 1981); soil, plant debris, bark of recently dead trees (Farr et al, 2008)	yes (Sumbali and Mehrotra, 1981)	yes (Teng, 1996; Tai, 1979)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no

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Bispora betulina (Corda) Hughes, 1958 (Ascomycota: Ascomycetes: Leotiales: Leotiaceae)	-	Farr et al, 2007	wood (Liu and Morrell, 1998)	no	yes (Wu et al, 2005)	yes (Landcare Report for MAF, 2003; Landcare NZFUNGI, 2009)	no
Botryosphaeria berengeriana f.sp. *pyricola* (Nose) Kogan. and Sakuma, 1984 (Ascomycota: Ascomycetes: Dothideales: Botryosphaeriaceae)	apple ring rot	CAB International, 1996; Zhang and Huang, 1990	fruit (Li et al, 1997); branches, leaves, shoots, fruit (CPC, 2007)	yes (CPC, 2007; Li et al, 1997)	yes (AQSIQ, 2007; Li et al, 1997)	yes (synonym for *B. dothidea*) (Pennycook, 1989; Landcare NZFUNGI, 2007;)	no*
Botryosphaeria dothidea (anamorph *Fusicoccum aesculi*) (Moug.) Ces. and De Not., 1863 (Ascomycota: Ascomycetes: Dothideales: Botryosphaeriaceae)	white rot	Farr et al, 1989; Jones and Aldwinckle, 1990	stems, fruit (PPIN, 2008); fruit (Jones and Aldwinckle, 1990); fruit, branches (Atkinson, 1971; Jones and Aldwinckle, 1990); dead limbs (Teng, 1996)	yes (Jones and Aldwinckle, 1990; PPIN, 2008)	yes (Zhuang, 2005; Teng, 1996)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Botryosphaeria fusca (Stevens) (nom. ined.) (Ascomycota: Ascomycetes: Dothideales: Mycosphaerellaceae)	-	Farr et al, 2007; Farr et al, 1989	leaves, stems, limbs (Farr et al, 2008)	no	yes (Farr et al, 2008)	yes (Landcare NZFUNGI, 2008)	no
Botryosphaeria obtusa (anamorph *Sphaeropsis malorum*) (Schwein.) Shoemaker, 1964 (Ascomycota: Ascomycetes: Dothideales: Botryosphaeriaceae)	black rot of apple and pear	Jones and Aldwinckle, 1990; Pennycook, 1989	wood, bark, stems, buds (PPIN, 2008); fruit, leaves, limbs (Jones and Aldwinckle, 1990)	yes (Jones and Aldwinckle, 1990)	yes (Zhuang, 2005; Teng, 1996)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Botryosphaeria parva (anamorph *Fusicoccum parvum*) Pennycook and Samuels, 1985 (Ascomycota: Ascomycetes: Dothideales: Botryosphaeriaceae)	-	Farr et al, 2007; Gadgil, 2005	stems (PPIN, 2008); fruit (Everett et al, 2007)	yes (avocado (Everett et al, 2007))	yes (Farr et al, 2008)	yes (Pennycook, 1989; Landcare NZFUNGI, 2007; Miller et al, 2006)	no
Botryosphaeria rhodina (anamorph *Lasiodiplodia theobromae*) (Berk. and Curtis) Arx, 1970 (Ascomycota: Ascomycetes: Dothideales: Botryosphaeriaceae)	diplodia pod rot of cocoa	Singh et al, 1990; Farr et al, 1989	fruit (Srivastava and Tripathi, 2003); limbs (Farr et al, 1989; Farr et al, 2007)	yes (CPC, 2007; Srivastava and Tripathi, 2003)	yes (CPC, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Botryosphaeria ribis (anamorph *Fusicoccum ribis*) Grossenb. and Duggar, 1911 (Ascomycota: Ascomycetes: Dothideales: Botryosphaeriaceae)	black rot of fruit	Farr et al, 1989; She et al, 2005	fruit (Farr et al, 1989); stems, branches, twigs, fruit (Farr et al, 2007)	yes (Farr et al, 1989)	yes (Zhang and Huang, 1990; Zhang and Liu, 2006)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no

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Botryosphaeria stevensii (anamorph *Diplodia mutila*) Shoemaker, 1964 (Ascomycota: Ascomycetes: Dothideales: Botryosphaeriaceae)	-	Farr et al, 2007; Pennycook, 1989	stems (PPIN, 2008); branches (Jones and Aldwinckle, 1990); leaves, stems (CPC, 2007); intercepted on pear fruit from Australia (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (Farr et al, 2008; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Botryotinia fuckeliana (anamorph *Botrytis cinerea*) (de Bary) Whetzel, 1945 (Ascomycota: Ascomycetes: Helotiales: Sclerotiniaceae)	grey mould	Pennycook, 1989; White et al, 1990	shoots, stems, leaves, flowers, fruit (PPIN, 2008); fruit (Jones and Aldwinckle, 1990); twigs (White et al, 1990)	yes (PPIN, 2008; Jones and Aldwinckle, 1990)	yes (Zhuang, 2005; Teng, 1996)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	no
Calonectria kyotensis (anamorph *Cylindrocladium floridanum*) Terash., 1968 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	-	PPIN, 2008; Landcare NZFUNGI, 2007	leaf spot, blight and crown rot (Polizzi et al, 2006)	no	yes (Farr et al, 2008)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	no
Capnophaeum fuliginoides (Rehm) Yamam., 1954 (Ascomycota: Ascomycetes: Capnodiales: Capnodiaceae)	sooty mould	Farr et al, 2007	dry branches (Saccardo, 1882)	no	yes (Farr et al, 2007)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2007)	no
Cephalotrichum stemonitis (Pers.) Nees, 1809 (mitosporic fungi)	-	Farr et al, 2007	wood (Ocete et al, 2002); soil (Cabello and Arambarri, 2002)	no	yes (Farr et al, 2008; Bai, 2002)	yes (Pennycook and Galloway, 2004; Landcare NZFUNGI, 2008)	no
Chaetomium globosum Kunze, 1817 (Ascomycota: Ascomycetes: Sordariales: Chaetomiaceae)	-	Farr et al, 1989; Ismail and Abdalla, 2005	fruit (Ismail and Abdalla, 2005); decayed straw and bamboo shoots (Teng, 1996)	yes (Ismail and Abdalla, 2005)	yes (Teng, 1996; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Falloon, 1985; PPIN, 2008)	no
Chondrostereum purpureum (Pers.) Pouzar, 1959 (Basidiomycota: Basidiomycetes: Polyporales: Meruliaceae)	silver leaf	Pennycook, 1989; White et al, 1990	wood, trunk, stem, leaves (PPIN, 2008; Jones and Aldwinckle, 1990); leaves, shoots (White et al, 1990); saprobic on recently dead or parasitic on living hardwoods (Farr et al, 2007)	no	yes (Ran, 2002; Zhuang, 2005)	yes (Pennycook, 1989; White et al, 1990)	no

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Cladosporium aecidiicola Thüm., 1876 (mitosporic fungi)	-	Farr et al, 2007	leaves (Braun and Rogerson, 1995); hyperparasitic on rust aecia (Landcare NZFUNGI, 2007)	no	yes (Farr et al, 2008; Guo, 2001)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Cladosporium cladosporioides (Fresen) De Vries, 1952 (mitosporic fungi)	-	Farr et al, 2007; MAFBNZ, 2009	fruit rot (Neeta et al, 2006)	yes ("fruit" (Neeta et al, 2006), MAFBNZ, 2009)	yes (Farr et al, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 2003; PPIN, 2008)	no
Cladosporium stenosporum Berk. and Curtis, 1875 (mitosporic fungi)	-	Farr et al, 2007; Saccardo, 1886a	leaves (Saccardo, 1886a)	no	yes (Farr et al, 2007)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Cochliobolus geniculatus (anamorph *Curvularia geniculata*) Nelson, 1964 (Ascomycota: Ascomycetes: Dothideales: Pleosporaceae)	leaf spot	Farr et al, 2007; Farr et al, 1989	seeds, seedlings (Farr et al, 2007); glumes of Oryzae (Teng, 1996)	no	yes (Teng, 1996; Farr et al, 2008)	yes (Pennycook and Galloway, 2004; Landcare NZFUNGI, 2008)	no
Colletotrichum acutatum Simmonds, 1965 (mitosporic fungi)	-	Farr et al, 2007; PPIN, 2008	fruit, stems, leaves (PPIN, 2008); fruit rot (Farr et al, 2007)	yes (PPIN, 2008)	yes (CPC, 2007; Farr et al, 2008)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Colletotrichum piri f. *tirolense* (Bubák) Sacc. and Sacc., 1906 (mitosporic fungi)	-	Tai, 1979; Saccardo, 1906a	leaves (Saccardo, 1906a)	no	yes (Farr et al, 2007; Tai, 1979)	no (not recorded in: Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Coniothecium chomatosporum Corda, 1837 (Basidiomycota: Urediniomycetes: Uredinales: Coleosporiaceae)	-	Farr et al, 2007	stems (Bose and Sindhan, 1976); branches (Dey and Singh, 1939)	no	yes (Farr et al, 2008)	no (not recorded in: Landcare NZFUNGI, 2007; PPIN, 2008)	no
Coniothecium intricatum Peck, 1896 (Basidiomycota: Urediniomycetes: Uredinales: Coleosporiaceae)	-	Tai, 1979; Saccardo, 1899	branches (Saccardo, 1899)	no	yes (Farr et al, 2007; Tai, 1979)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Coniothyrium piricola Potebnia, 1907 (mitosporic fungi)	-	Tai, 1979; Zhuang, 2005	leaves (Rodionova, 1973)	no	yes (Tai, 1979; Zhuang, 2005)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Coniothyrium tirolense Bubák, 1904 (mitosporic fungi)	-	Tai, 1979; Zhuang, 2005	leaves (Saccardo, 1906b)	no	yes (Tai, 1979; Zhuang, 2005)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no

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Corticium centrifugum (Weinm.) Fr., 1874 (Basidiomycota: Basidiomycetes: Polyporales: Corticiaceae)	-	Tai, 1979; Klingner and Linardelli, 1988	fruit (Cheo, 1936); storage rot (Bielenin, 1986)	yes (apples (Bielenin, 1986), Cheo, 1936)	yes (Zhang and Huang, 1990; Cheo, 1936)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no*
Corynespora cassiicola (Berk. and Curtis) Wei, 1950 (mitosporic fungi)	-	Braun and Crous, 2003; Farr et al, 1989	leaves (Farr et al, 1989; Farr et al, 2007); fruit, leaves, stems (CPC, 2007); fruit (Anjli et al, 2005)	yes (papaya (Anjli et al, 2005))	yes (Farr et al, 2008; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Cosmospora aurantiicola (anamorph *Fusarium larvarum*) (Berk. and Broome) Rossman and Samuels, 1999 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	-	Booth, 1981	Entomopathogenic on scale insects (Tyson et al, 2005): possibly associated with Coccidae on *Pyrus* fruit.	yes (possible association)	yes (Farr et al, 2008; CPC, 2007)	yes (Tyson et al, 2005; Landcare NZFUNGI, 2007)	no
Cosmospora flammea (anamorph *Fusarium coccophilum*) (Tul. and C. Tul.) Rossman and Samuels, 1999 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	-	Farr et al, 2007; Landcare NZFUNGI, 2007	Entomopathogenic on scale insects (Tyson et al, 2005): possibly associated with Coccidae on *Pyrus* fruit.	yes (possible association)	yes (Gao and Ouyang, 1981; Song, 2002)	yes (Tyson et al, 2005; Landcare NZFUNGI, 2007)	no
Curvularia inaequalis (Shear) Boedijn, 1933 (mitosporic fungi)	leaf mould	Farr et al, 2007; Farr et al, 1989	leaves in maize (Dai et al, 1998)	no	yes (Hou and Shi, 2000; Jin et al, 1994)	yes (Landcare NZFUNGI, 2007; Pennycook, 2003)	no
Cylindrocarpon didymum (Harting) Wollenw., 1924 (mitosporic fungi)	-	Farr et al, 2007	roots, seedlings (Farr et al, 2008; Brayford, 1987a)	no	yes (CPC, 2007; Zhang et al, 1991)	yes (Landcare NZFUNGI, 2007; PPIN, 2008; Brayford, 1987a)	no
Cylindrocarpon obtusisporum (Cooke and Harkn.) Wollenw., 1916 (mitosporic fungi)	canker	Farr et al, 2007; Farr et al, 1989	roots, soil (Farr et al, 2007); root rots (Brayford, 1987b)	no	yes (Zhang et al, 1991)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Cytospora carphosperma Fr., 1823 (mitosporic fungi)	canker	Tai, 1979; AQSIQ, 2007	wood, dying twigs (Farr et al, 2008)	no	yes (Farr et al, 2007; AQSIQ, 2007)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Cytospora rubescens Fr., 1823 (mitosporic fungi)	-	Farr et al, 2007	branches (Abbruzzetti, 1997; Treshow and Scholes, 1958)	no	yes (Zhuang, 2005; Farr et al, 2008)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Cytospora sp. (mitosporic fungi)	-	Farr et al, 2007; Farr et al, 1989	canker (Farr et al, 1989; Farr et al, 2007)	no	yes (Farr et al, 2007)	unknown	no

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Diaporthe eres (anamorph *Phomopsis oblonga*) Nitschke, 1870 (Ascomycota: Ascomycetes: Diaporthales: Valsaceae)	pear canker	Farr et al, 1989; Gadgil, 2005	twig blight (Farr et al, 1989; Farr et al, 2007); dieback (Vajna, 2002); leaves, petioles, twigs, branches, stems, flowers, fruit (Farr et al, 2007)	yes ("fruit" (Farr et al, 2008))	yes (Tai, 1979; Ciferri, 1955)	yes (Landcare NZFUNGI, 2007; Nursery stock research and extension committee NZ, 1956)	no
Diaporthe perniciosa (anamorph *Phomopsis mali*) Marchal and É.J. Marchal, 1921 (Ascomycota: Ascomycetes: Diaporthales: Valsaceae)	-	Jones and Aldwinckle, 1990; Pennycook, 1989	wood, stems, roots, fruit (PPIN, 2008); branches, fruit (Jones and Aldwinckle, 1990); bark canker (Farr et al, 1989; Farr et al, 2007)	yes (PPIN, 2008; Jones and Aldwinckle, 1990)	yes (Farr et al, 2008)	yes (Pennycook, 1989; Brook, 1960)	no
Diaporthe phaseolorum (anamorph *Phomopsis phaseoli*) (Cooke and Ellis) Sacc., 1882 (Ascomycota: Ascomycetes: Diaporthales: Valsaceae)	-	PPIN, 2008	buds, shoots (PPIN, 2008); stem canker (Farr et al, 2007); fruit (Hampton et al, 1983)	yes (tamarillo (Hampton et al, 1983))	yes (Zhang and Huang, 1990; Punithalingam and Holliday, 1972)	yes (Pennycook, 1989; Hampton et al, 1983)	no
Diatrype stigma (Hoffm.) Fr., 1849 (Ascomycota: Ascomycetes: Diatrypales: Diatrypaceae)	leaf spot	Farr et al, 2007	dead bark (Ohira, 1974); stem necrosis (Shutyaev, 1991)	no	yes (Teng, 1996; Farr et al, 2008)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Diplocarpon mespili (anamorph *Entomosporium mespili*) (Sorauer) Sutton, 1980 (Ascomycota: Ascomycetes: Helotiales: Dermateaceae)	fabraea leaf and fruit spot	Sivanesan and Gibson, 1976; Farr et al, 1989	leaves, fruit (Farr et al, 1989; Chavez-Alfaro et al, 1995; PPIN, 2008); leaves, shoots (Jones and Aldwinckle, 1990)	yes (Chavez-Alfaro et al, 1995; Farr et al, 1989)	yes (Zhuang, 2005; Farr et al, 2008)	yes (Pennycook, 1989; White et al, 1990)	no
Discostroma corticola (anamorph *Seimatosporium lichenicola*) (Fuckel) Brockmann, 1976 (Ascomycota: Ascomycetes: Xylariales: Amphisphaeriaceae)	-	Khomyakov, 1984; Farr et al, 2007	leaves, twigs (Farr et al, 2007); bark (Khomyakov, 1984)	no	yes (Farr et al, 2008)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Elsinoë pyri (anamorph *Sphaceloma pyrinum*) (Woron.) Jenkins, 1932 (Ascomycota: Ascomycetes: Myriangiales: Elsinoaceae)	elsinoe spot	Dingley, 1969; Farr et al, 1989	leaves, fruit (Farr et al, 1989; Atkinson, 1971)	yes (Farr et al, 1989; Atkinson, 1971)	yes (Ciferri, 1955)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Epicoccum nigrum Link, 1815 (mitosporic fungi)	red blotch of grains	Popushoi and Chobanu, 1991; CPC, 2007	stored fruit decay (Popushoi and Chobanu, 1991)	yes (Popushoi and Chobanu, 1991)	yes (Zhuang, 2005; Farr et al, 2008)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no

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Erythricium salmonicolor (anamorph *Necator decretus*) (Berk. and Broome) Burds., 1985 (Basidiomycota: Basidiomycetes: Stereales: Hyphodermataceae)	pink disease	Farr et al, 2007; Dingley, 1969	branches, twigs (Farr et al, 1989); bark, branches, leaves (CPC, 2007)	no	yes (CPC, 2007; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Eutypella stellulata (Fr.) Sacc., 1882 (Ascomycota: Ascomycetes: Diatrypales: Diatrypaceae)	-	Landcare NZFUNGI, 2007; PPIN, 2008	wood (PPIN, 2008); twigs (Teng, 1996)	no	yes (Teng, 1996)	yes (Landcare NZFUNGI, 2008; PPIN, 2008)	no
Fomes fomentarius (L.) Kickx, 1867 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	-	Farr et al, 2007; Tai, 1979	trunks (Teng, 1996); wood (Huang and Dai, 2005)	no	yes (Bau et al, 2007; Teng, 1996)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Fomes truncatosporus (Lloyd) Teng, 1963 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	heart rot	Farr et al, 2007; Biosecurity Australia, 2005	trunks (Teng, 1996)	no	yes (Farr et al, 2007; Teng, 1996)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Fomitopsis pinicola (Sw.) Karst., 1881 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	brown crumbly rot	CPC, 2007; Farr et al, 1989	trunks (Teng, 1996); wood (Farr et al, 2007; Teng, 1996); stumps and rotten wood (Zhuang, 2005)	no	yes (Teng, 1996; Zhuang, 2005)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Fusarium merismoides Corda, 1838 (mitosporic fungi)	basal stem rot	Farr et al, 2007; Farr et al, 1989	Usually considered a soil saprobe but commonly isolated from a wide variety of plant materials (Farr et al, 2008)	no	yes (Farr et al, 2008; Fu and Chen, 1989)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Fusarium oxysporum Schltdl., 1824 (mitosporic fungi)	-	Farr et al, 1989; PPIN, 2008	leaves, fruit (Brayford, 1992); fruit (Joffe, 1972)	yes (avocado, banana, citrus (Joffe, 1972))	yes (CPC, 2007; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; Falloon, 1985)	no
Fusarium redolens Wollenw., 1913 (mitosporic fungi)	-	Farr et al, 2007; Farr et al, 1989	roots (Booth and Waterston, 1964b)	no	yes (Farr et al, 2008)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no

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Fusicladium pyricola - (mitosporic fungi)	-	Farr et al, 2007; Zhuang, 2005	*Fusicladium* spp. and the associated *Venturia* teleomorphs are found on fruit, leaves and stems (Beck et al, 2005).	yes (*Fusicladium* spp. are found on fruit of Rosaceae (Beck et al, 2005))	yes (Farr et al, 2007; Zhuang, 2005)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no*
Ganoderma applanatum (Pers.) Pat., 1887 (Basidiomycota: Basidiomycetes: Ganodermatales: Ganodermataceae)	-	Farr et al, 2007	wood (Farr et al, 2007; Teng, 1996; Zhuang, 2005)	no	yes (Teng, 1996; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Ganoderma australe (Fr.) Pat., 1890 (Basidiomycota: Basidiomycetes: Ganodermatales: Ganodermataceae)	white heart rot	Dingley, 1969; Pennycook, 1989	wood (Farr et al, 2007)	no	yes (Dai et al, 2004b)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Gibberella acuminata (anamorph *Fusarium acuminatum*) Wollenw., 1943 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	-	Farr et al, 2007; Farr et al, 1989	twig blight (Farr et al, 1989; Farr et al, 2007); fruit (Sumbali and Badyal, 1990)	yes (apple (Sumbali and Badyal, 1990))	yes (Farr et al, 2008; Zhao, 2001)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Gibberella avenacea (anamorph *Fusarium avenaceum*) Cook, 1967 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	Fusarium blight	Farr et al, 1989; Booth and Waterston, 1964	twigs (Farr et al, 1989; Farr et al, 2007); branches (PPIN, 2008); fruit (Booth and Waterston, 1964a)	yes (Booth and Waterston, 1964)	yes (Zhang and Huang, 1990; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Gibberella baccata (anamorph *Fusarium lateritium*) (Wallr.) Sacc., 1878 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	collar rot, Gibberella canker	Pennycook, 1989; Farr et al, 1989	twig blight (Farr et al, 2007); canker (Farr et al, 1989); wood, branch, stem, bud, fruit (PPIN, 2008)	yes (PPIN, 2008)	yes (CPC, 2007; Farr et al, 2008)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Gibberella fujikuroi (anamorph *Fusarium moniliforme*) (Sawada) Wollenw., 1931 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	-	Farr et al, 2007	fruit, flowers, leaves, roots, seeds, stems (CPC, 2007); fruit (Pramod et al, 2007)	yes (all hosts (CPC, 2007), papaya (Pramod et al, 2007))	yes (Zhang and Huang, 1990; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Gibberella intricans (anamorph *Fusarium equiseti*) Wollenw., 1930 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	-	Farr et al, 2007; Farr et al, 1989	stalk rot of maize (Farr et al); fruit (Joffe, 1972)	yes (avocado (Joffe, 1972))	yes (CPC, 2007; Farr et al, 2008)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no

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Gibberella pulicaris (anamorph *Fusarium sambucinum*) (Fr.) Sacc., 1877 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	-	Farr et al, 2007; Farr et al, 1989	twig blight (Farr et al, 1989; Farr et al, 2007); culms (Teng, 1996); root rots, storage rots (Booth, 1973); fruit (Darvas and Kotze, 1987)	yes (avocado (Darvas and Kotze, 1987))	yes (Teng, 1996; Farr et al, 2008)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989)	no
Glomerella cingulata (anamorph *Colletotrichum gloeosporioides*) (Stoneman) Spauld. and Schrenk, 1903 (Ascomycota: Ascomycetes: Phyllachorales: Phyllachoraceae)	anthracnose	Farr et al, 1989; Pennycook, 1989	fruit (Farr et al, 1989); root, leaf, fruit, stem, flower (PPIN, 2008); leaves, twigs (Teng, 1996)	yes (CPC, 2007; Jones and Aldwinckle, 1990)	yes (Zhuang, 2005; Teng, 1996)	yes (Landcare NZFUNGI, 2008; Taylor, 1923)	no*
Gymnosporangium asiaticum Miyabe ex G.Yamada, 1904 (Basidiomycota: Urediniomycetes: Uredinales: Pucciniaceae)	Japanese pear rust	Zhang and Huang, 1990; Watanabe and Yasunobu, 1963	leaves (Jones and Aldwinckle, 1990; Teng, 1996); leaves, stems (Kern, 1973); Biosecurity Australia (2005) states that this rust fungus is associated with fruit	unknown	yes (Teng, 1996; Zhang and Huang, 1990)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no*
Gymnosporangium clavariiforme (Wulfen) DC., 1805 (Basidiomycota: Urediniomycetes: Uredinales: Pucciniaceae)	European hawthorn rust	Farr et al, 1989; Kern, 1973	leaves, stems, fruit (Laundon, 1977a); leaves, twigs (Kern, 1973)	yes (Laundon, 1977a)	yes (Farr et al, 2008; Tai, 1979)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no*
Gymnosporangium confusum Plowr., 1889 (Basidiomycota: Urediniomycetes: Uredinales: Pucciniaceae)	hawthorn rust	Laundon, 1977b, Jones and Aldwinckle, 1990	mainly leaves, also stems, calyces, fruit (Laundon, 1977b)	yes (aecial hosts (Laundon, 1977b))	yes (Zhuang, 2005; Farr et al, 2008)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no*
Gymnosporangium cunninghamianum Barclay, 1890 (Basidiomycota: Urediniomycetes: Uredinales: Pucciniaceae)	rust	Jones and Aldwinckle, 1990; Kern, 1973	leaves (Kern, 1973)	no	yes (Kern, 1973; Farr et al, 2008)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no
Gymnosporangium fuscum DC., 1805 (Basidiomycota: Urediniomycetes: Uredinales: Pucciniaceae)	European pear rust	Kern, 1973; Farr et al, 1989	leaves, fruit (Jones and Aldwinckle, 1990; CPC, 2007); branches (Juhasova and Praslicka, 2002; Grasso, 1963)	yes (Jones and Aldwinckle, 1990; Grasso, 1956)	yes (Wang and Guo, 1985; Zhuang, 2005)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	yes

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Gymnosporangium yamadae Miyabe ex G.Yamada, 1904 (Basidiomycota: Urediniomycetes: Uredinales: Pucciniaceae)	Japanese apple rust	Tai, 1979	leaves, twigs (Teng, 1996); aecia on leaves, rarely on stems and fruit (Laundon, 1977d)	no (apple, rarely (Laundon, 1977d))	yes (Kern, 1973; Teng, 1996)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no*
Haematonectria haematococca (anamorph *Fusarium solani*) (Berk. and Broome) Samuels and Rossman, 1999 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	dry rot of potato	Sharma et al, 1984; Farr et al, 1989	roots (PPIN, 2008); fruit (Sharma et al, 1984)	yes (Sharma et al, 1984)	yes (Zhang and Huang, 1990; Zhuang, 2005)	yes (Pennycook, 1989; Landcare NZFUNGI, 2007; Falloon, 1985)	no
Hapalopilus rutilans (Pers.) Karst., 1881 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	sapwood rot	Farr et al, 2007; Farr et al, 1989	white rot (Farr et al, 1989); dead wood (Teng, 1996; Huang and Dai, 2005)	no	yes (Teng, 1996; Huang and Dai, 2005)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Helicobasidium mompa Tanaka, 1891 (Basidiomycota: Ustomycetes: Platygloeales: Platygloeaceae)	violet root rot	Farr et al, 2007; Tai, 1979	roots (Nakamura, 2004)	no	yes (Zhang and Huang, 1990; Tai, 1979)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Hendersonia piricola Sacc., 1875 (mitosporic fungi)	-	Tai, 1979; Saccardo, 1884	leaves (Saccardo, 1884)	no	yes (Farr et al, 2007; Tai, 1979)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Heterobasidion annosum (anamorph *Spiniger meineckellum*) (Fr.) Bref., 1888 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	Heterobasid-ion root rot	CPC, 2007	stumps, trunks (Farr et al, 2007)	no	yes (Teng, 1996; Zhuang, 2005)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Hypocrea ceramica (anamorph *Trichoderma koningii*) Ellis and Everh., 1892 (Ascomycota: Ascomycetes: Hypocreales: Hypocreaceae)	trichoderma rot	Farr et al, 2007; Farr et al, 1989	a fungal antagonist (mycoparasite)	yes (likely)	yes (Teng, 1996; CPC, 2007)	yes (Pennycook, 1989; Falloon, 1985)	no
Hypoxylon rubiginosum (Pers.) Fr., 1849 (Ascomycota: Ascomycetes: Xylariales: Xylariaceae)	-	Farr et al, 2007; Farr et al, 1989	wood, bark (Teng, 1996); dead branches (Zhuang, 2005)	no	yes (Teng, 1996; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook and Galloway, 2004)	no
Hypoxylon serpens (anamorph *Geniculosporium serpens*) (Pers.) Fr., 1835 (Ascomycota: Ascomycetes: Xylariales: Xylariaceae)	wood rot: tea	CPC, 2007	logs and stumps (Hawksworth, 1972a)	no	yes (Farr et al, 2008; Sun et al, 2007)	yes (Landcare NZFUNGI, 2008; Pennycook and Galloway, 2004)	no

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Inonotus hispidus (Bull.) Karst., 1880 (Basidiomycota: Basidiomycetes: Hymenochaetales: Hymenochaetaceae)	heart rot	CPC, 2007; Pegler and Waterston, 1968a	heart rot of ash (Pegler and Waterston, 1968a)	no	yes (Zhuang, 2005; Bau et al, 2007)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Kretzschmaria deusta (Hoffm.) Martin, 1970 (Ascomycota: Ascomycetes: Xylariales: Xylariaceae)	-	Farr et al, 2007	wood decay (Hawksworth, 1972b)	no	yes (Zhang and Chee, 1989)	yes (Landcare NZFUNGI, 2008)	no
Laetiporus sulphureus (anamorph *Sporotrichum versisporum*) (Bull.) Murril, 1920 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	-	Farr et al, 2007; Farr et al, 1989	rotten wood (Zhuang, 2005; Farr et al, 2008)	no	yes (Zhuang, 2005; Bau et al, 2007)	no (not recorded in: Landcare NZFUNGI, 2008)	no
Lepteutypa cupressi (anamorph *Seiridium unicorne*) (Nattrass, Booth and Sutton) Swart, 1973 (Ascomycota: Ascomycetes: Xylariales: Amphisphaeriaceae)	cypress canker	Farr et al, 2007; Tai, 1979	stems of young trees (Booth and Gibson, 1972)	no	yes (Farr et al, 2007; Tai, 1979)	yes (Landcare NZFUNGI, 2008)	no
Leptosphaeria coniothyrium (anamorph *Coniothyrium fuckelii*) Saccardo, 1875 (Ascomycota: Ascomycetes: Dothideales: Leptosphaeriaceae)	-	Farr et al, 2007	leaves, stems (CPC, 2007); stems (Crane and Shearer, 1991)	no	yes (CPC, 2007; CAB International, 1978)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Leptosphaeria pomona Sacc., 1876 (Ascomycota: Ascomycetes: Dothideales: Leptosphaeriaceae)	fruit rot	Yu, 1940	fruit rot (Yu, 1940); leaves of *Pyrus malus* (=*Malus domestica*) (Crane and Shearer, 1991)	yes (Yu, 1940)	yes (Yu, 1940)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	yes
Leucostoma auerswaldii (Nitschke) Höhn., 1928 (Ascomycota: Ascomycetes: Diaporthales: Valsaceae)	leucostoma canker	Farr et al, 2007	branches (Jones and Aldwinckle, 1990)	no	yes (Farr et al, 2008)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Leucostoma persoonii (Nitschke) Höhn., 1928 (Ascomycota: Ascomycetes: Diaporthales: Valsaceae)	twig blight	Farr et al, 1989; Chavez-Alfaro et al, 1995	twigs, bark (Hayova and Minter, 1998a); branches (Chavez-Alfaro et al, 1995)	no	yes (Zhuang, 2005; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no

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Macrophoma kawatsukai Hara (mitosporic fungi) (anamorph of *Botryosphaeria berengeriana* f.sp. *pyricola*)	macrophoma rot	Tai, 1979; Lin et al, 2002	fruit (Lin et al, 2002)	yes (Lin et al, 2002)	yes (Zhang and Huang, 1990; Zhuang, 2005)	yes (anamorph of *Botryosphaeria berengeriana* f.sp. *pyricola*) Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Macrophomina phaseolina (Tassi) Goidanich, 1947 (mitosporic fungi)	charcoal rot of bean/ tobacco	Farr et al, 2007	stem rot, canker, sometimes leaves (Holliday and Punithalingam, 1970)	no	yes (Zhang and Huang, 1990; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Macrosporium pyrorum Cooke (mitosporic fungi)	-	Tai, 1979; Yu, 1940	fruit rot (Yu, 1940); leaves (Saccardo, 1886b)	yes (Yu, 1940)	yes (Tai, 1979; Yu, 1940)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	yes
Marssonina neilliae (Harkn.) Magnus, 1906 (mitosporic fungi)	-	Farr et al, 2007; Tai, 1979	leaves (Indexfungorum, 2008)	no	yes (Farr et al, 2007; Tai, 1979)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no
Microsphaeropsis olivacea (Bonord.) Höhn., 1917 (mitosporic fungi)	-	Shoshiashvili and Dzagnidze, 1968	leaves (Andrews et al, 1983); branches, twigs (Ecological flora of the British Isles, 2008)	no	yes (Farr et al, 2008; Zheng et al, 1996)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Monilinia fructicola (anamorph *Monilia fructicola*) (Winter) Honey, 1928 (Ascomycota: Ascomycetes: Helotiales: Sclerotiniaceae)	American brown rot	Jones and Aldwinckle, 1990; Chavez-Alfaro et al, 1995	fruit (PPIN, 2008; Jones and Aldwinckle, 1990; Atkinson, 1971)	yes (Jones and Aldwinckle, 1990; Atkinson, 1971)	yes (CPC, 2007; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Monilinia fructigena (anamorph *Monilia fructigena*) (Aderh. and Ruhland) Honey, 1936 (Ascomycota: Ascomycetes: Helotiales: Sclerotiniaceae)	European brown rot	Farr et al, 1989; Jones and Aldwinckle, 1990	fruit (Jones and Aldwinckle, 1990; Mordue, 1979a)	yes (CPC, 2007; Mordue, 1979a))	yes (Garland, 1995; Zhuang, 2005)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2007; PPIN, 2008)	yes

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Monilinia laxa (anamorph *Monilia laxa*) (Aderh. and Ruhland) Honey, 1945 (Ascomycota: Ascomycetes: Helotiales: Sclerotiniaceae)	European brown rot	Mordue, 1979b; Pennycook, 1989	brown rot (Farr et al, 1989; Farr et al, 2007); shoots (PPIN, 2008); rarely fruit (Jones and Aldwinckle, 1990); fruit, blossoms, twigs, leaves (Mordue, 1979b).	yes (Mordue, 1979b; Jones and Aldwinckle, 1990)	yes (Mordue, 1979b; Farr et al, 2007)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Monochaetia turgida (Atk.) Sacc., 1906 (mitosporic fungi)	-	Farr et al, 2007; Tai, 1979	leaves (Farr et al, 2008)	no	yes (Farr et al, 2007; Tai, 1979)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Mucor mucedo Fresen., 1850 (Zygomycota: Zygomycetes: Mucorales: Mucoraceae)	mucor rot	Farr et al, 2007	fruit (Shaista, 2006; Eseigbe and Bankole, 1996)	yes (plums (Eseigbe and Bankole, 1996))	yes (Teng, 1996; Zhuang, 2005)	yes (Pennycook, 2003; Landcare NZFUNGI, 2007)	no
Mycosphaerella pomacearum (Crié) Oudem., 1905 (Ascomycota: Ascomycetes: Dothideales: Mycosphaerellaceae)	leaf spot	Farr et al, 2007; Podleckis and Usnick, 2005	leaves (Podleckis and Usnick, 2005)	no	yes (Farr et al, 2007; Podleckis and Usnick, 2005)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Mycosphaerella pomi (anamorph *Cylindrosporium pomi*) (Pass.) Lindau, 1897 (Ascomycota: Ascomycetes: Dothideales: Mycosphaerellaceae)	Brooks fruit spot	Iwanami et al, 2000	fruit spot (Iwanami et al, 2000); fruit, leaves (Arai et al, 2005)	yes (Iwanami et al, 2000)	yes (Xu et al, 2000)	yes (Atkinson, 1971; Landcare NZFUNGI, 2008)	no
Mycosphaerella pyri (anamorph *Septoria pyricola)* (Auersw.) Boerema, 1970 (Ascomycota: Ascomycetes: Dothideales: Mycosphaerellaceae)	leaf fleck of pear	Sivanesan, 1990; Farr et al, 1989	fruit, leaves (Farr et al, 1989; Sivanesan, 1990)	yes (Sivanesan, 1990; Farr et al, 1989)	yes (Sivanesan, 1990; AQSIQ, 2007)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	yes
Mycosphaerella tassiana (anamorph *Cladosporium herbarum*) (De Not.) Johanson, 1884 (Ascomycota: Ascomycetes: Dothideales: Mycosphaerellaceae)	rot of pepper fruit	Sugar and Basile, 2007; Jones and Aldwinckle, 1990	flowers (PPIN, 2008); fruit (Jones and Aldwinckle, 1990; Sugar and Basile, 2007); leaves, culms and glumes of Gramineae (Teng, 1996)	yes (Jones and Aldwinckle, 1990)	yes (CPC, 2007; Teng, 1996)	yes (PPIN, 2008; Landcare NZFUNGI, 2008)	no

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Nectria cinnabarina (anamorph *Tubercularia vulgaris*) (Tode) Fr., 1849 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	Nectria twig blight	Pennycook, 1989; Chavez-Alfaro et al, 1995	canker (Farr et al, 1989); twigs (PPIN, 2008); branches (Chavez-Alfaro et al, 1995)	no	yes (Teng, 1996; Zhuang, 2005)	yes (CAB International, 2000a; Landcare NZFUNGI, 2008)	no
Nectria pseudotrichia (anamorph *Tubercularia lateritia*) (Schwein.) Berk. and Curtis, 1853 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	-	Farr et al, 2007	stem canker (Becker, 2003); stem end rot in avocados (Sanders and Korsten, 2002); bark, twigs, leaves and fruit of avocado trees (Darvas et al, 1987)	yes (avocados (Sanders and Korsten, 2002), avocado trees (Darvas et al, 1987))	yes (Mycobank, 2008)	yes (Landcare NZFUNGI, 2008)	no
Neofabraea alba (anamorph *Phlyctema vagabunda*) (Guthrie) Verkley, 1999 (Ascomycota: Ascomycetes: Helotiales: Dermateaceae)	-	Dingley, 1969; Pennycook, 1989	branches, fruit (Henriquez et al, 2006)	yes (Henriquez et al, 2006)	yes (Farr et al, 2007; Tai, 1979)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Neofabraea malicorticis (anamorph *Cryptosporiopsis curvispora*) Jacks., 1913 (Ascomycota: Ascomycetes: Helotiales: Dermateaceae)	bulls-eye rot	Pennycook, 1989; Kienholz, 1956	leaf, stem (PPIN, 2008); fruit (Jones and Aldwinckle, 1990; Kienholz, 1956); wood, fruit (Atkinson, 1971; Jones and Aldwinckle, 1990)	yes (Kienholz, 1956; Jones and Aldwinckle, 1990)	yes (Farr et al, 2007; Tai, 1979)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Neonectria coccinea (anamorph *Cylindrocarpon candidum*) (Pers.) Rossman and Samuels, 1999 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	-	Farr et al, 2007; Farr et al, 1989	bark (Kunca, 2005; Booth, 1977)	no	yes (Farr et al, 2008; CABI, 2006a)	yes (Landcare NZFUNGI, 2008; CABI, 2006a)	no
Neonectria galligena (anamorph *Cylindrocarpon heteronema*) (Bres.) Rossman and Samuels, 1999 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	European canker	Jones and Aldwinckle, 1990; Farr et al, 1989	twigs, branches (Jones and Aldwinckle, 1990; PPIN, 2008); twigs (White et al, 1990); storage rot of fruit (Booth, 1967); fruit (Booth, 1967)	yes (Booth, 1967; Jones and Aldwinckle, 1990)	yes (CPC, 2007; as *Neonectria ditissima* (Farr et al, 2008))	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; White et al, 1990)	no
Neonectria radicicola (anamorph *Cylindrocarpon destructans* var. *destructans*) (Gerlach and Nilsson) Mantiri and Samuels, 2001 (Ascomycota: Ascomycetes: Hypocreales: Nectriaceae)	black root of strawberry	Farr et al, 1989; CPC, 2007	limb canker (Farr et al, 1989); buds, leaf scars and roots (Traquair and White, 1992)	no	yes (CPC, 2007; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no

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Ochropsora ariae (Fuckel) Ramsb., 1914 (Basidiomycota: Urediniomycetes: Uredinales: Chaconiaceae)	leaf rust	Farr et al, 2007; Tai, 1979	leaves (Indexfungorum, 2008)	no	yes (Farr et al, 2007; Zhuang, 2005)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Ovulariopsis sp. (mitosporic fungi)	powdery mildew	Farr et al, 2007	*Ovulariopsis* spp. are found on leaves (e.g. Ragunath, 1963)	no	yes (Farr et al, 2007; Zhuang, 2005)	unknown	no
Oxyporus latemarginatus (Durieu and Mont.) Donk, 1966 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	-	DeVay et al, 1968	root and crown rot (DeVay et al, 1968)	no	yes (Farr et al, 2007)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Passalora pyrophila Braun and Crous, 2003 (mitosporic fungi)	pear leaf spot	Zhang et al, 2000; Zhuang, 2005	leaves (Zhang et al, 2000)	no	yes (Zhuang, 2005; Braun and Crous, 2003)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Patellaria atrata (Hedw.) Fr., 1822 (Ascomycota: Ascomycetes: Patellariales: Patellariaceae)	-	Farr et al, 2007	wood (Teng, 1996); rotten wood (Zhuang, 2005)	no	yes (Teng, 1996; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008)	no
Penicillium aurantiogriseum Dierckx, 1901 (mitosporic fungi)	blue mould	Farr et al, 1989; Jones and Aldwinckle, 1990	fruit (Jones and Aldwinckle, 1990)	yes (Jones and Aldwinckle, 1990)	yes (Zhuang, 2005; Farr et al, 2008)	yes (Pennycook, 2003; Landcare NZFUNGI, 2007)	no
Penicillium chrysogenum Thom, 1910 (mitosporic fungi)	green fruit rot	Farr et al, 2007; Farr et al, 1989	roots, crowns (Sprague, 1957, cited in Farr et al, 2007); fruit rot (Verma and Tikoo, 2004)	yes (citrus (Verma and Tikoo, 2004))	yes (Zhuang, 2005; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Falloon, 1985)	no
Penicillium expansum Link, 1809 (mitosporic fungi)	blue mould	Farr et al, 1989; Pennycook, 1989	fruit (PPIN, 2008; Jones and Aldwinckle, 1990)	yes (Jones and Aldwinckle, 1990; Farr et al, 1989)	yes (Zhuang, 2005; AQSIQ, 2007)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	no
Penicillium italicum Wehmer, 1894 (mitosporic fungi)	blue mould	Tai, 1979; Dingley, 1969	fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (Zhang and Huang, 1990; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	no

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Penicillium rugulosum Thom, 1910 (mitosporic fungi)	blue mould	Farr et al, 2007; Farr et al, 1989	blue mould (Farr et al, 2007); fruit (Jones and Aldwinckle, 1990)	yes (apple (Jones and Aldwinckle, 1990))	yes (Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	no
Penicillium sp. Link, 1809 (mitosporic fungi)	rot	Farr et al, 2007; Farr et al, 1989	fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	See appendix 2	no*
Periconia byssoides Pers., 1801 (mitosporic fungi)	-	Farr et al, 2007	leaves (Teng, 1996; Prasad and Anil, 2005)	no	yes (Teng, 1996; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook and Galloway, 2004)	no
Pestalotiopsis breviseta (Sacc.) Steyaert, 1949 (mitosporic fungi)	-	Farr et al, 2007; Tai, 1979	leaves (Farr et al, 2008)	no	yes (Tai, 1979; Sun and Cao, 1990)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Pestalotiopsis maculans (Corda) Naj Raj, 1985 (mitosporic fungi)	-	Tai, 1979; Farr et al, 1989	leaves (Farr et al, 1989; Farr et al, 2007); shoots (Miller et al, 2006)	no	yes (Tai, 1979; Ge et al, 1993)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	no
Pestalotiopsis sorbi (Pat.) Sun and Ge, 1990 (mitosporic fungi)	-	Farr et al, 2007; Tai, 1979	leaves (Saccardo, 1892a)	no	yes (Farr et al, 2007; Sun and Ge, 1990)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Phaeodothis winteri (Niessl) Aptroot, 1995 (Ascomycota: Ascomycetes: Pleosporales: Phaeosphaeriaceae)	-	Farr et al, 2007	dead cabbage stem (IndexFungorum, 2008)	no	yes (Farr et al, 2008)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no
Phanerochaete sordida (Karst.) Erikss. and Ryvarden, 1978 (Basidiomycota: Basidiomycetes: Polyporales: Meruliaceae)	white rot	Farr et al, 2007	wood (Farr et al, 2008; Hirai et al, 1999)	no	yes (Farr et al, 2007; Mycobank, 2008)	yes (Landcare NZFUNGI, 2007)	no
Phellinus gilvus (Scwein.) Pat., 1900 (Basidiomycota: Basidiomycetes: Hymenochaetales: Hymenochaetaceae)	wood rot	Farr et al, 2007; Farr et al, 1989	wood (Teng, 1996; Huang and Dai, 2005)	no	yes (Teng, 1996; Zhuang, 2005)	yes (Landcare NZFUNGI, 2007)	no
Phellinus igniarius (L.) Quélet, 1886 (Basidiomycota: Basidiomycetes: Hymenochaetales: Hymenochaetaceae)	hardwood trunk rot	Farr et al, 2007; Farr et al, 1989	white heart rot (Farr et al, 1989); wood (Teng, 1996)	no	yes (Teng, 1996; Zhuang, 2005; Bau et al, 2007)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no

Scientific name	Common name	Associated with *Pyrus* spp. (ref)	Plant part association (all hosts)	Likely to be present on *Pyrus* fruit	Present in China	Present in New Zealand	Potential hazard*
Phellinus noxius (Corner) Cunn., 1965 (Basidiomycota: Basidiomycetes: Hymenochaetales: Hymenochaetaceae)	brown tea root disease	Farr et al, 2007	roots (Farid et al, 2006); wood (Tsai et al, 2005)	no	yes (CPC, 2007; Farr et al, 2008)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Phellinus pomaceus (Pers.) Maire, 1933 (Basidiomycota: Basidiomycetes: Hymenochaetales: Hymenochaetaceae)	-	Farr et al, 2007; Tai, 1979	trunks, branches (Teng, 1996); leaves, roots (CPC, 2007)	no	yes (Wang et al, 2001; Teng, 1996)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008)	no
Phoma exigua Desm., 1849 (mitosporic fungi)	-	Farr et al, 1989; White et al, 1990	storage rot (Farr et al, 1989; Farr et al, 2007); wood (White et al, 1990); fruit (Manning et al, 2003)	yes (Farr et al, 2007; Farr et al, 1989)	yes (Farr et al, 2007)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Phoma exigua var. *exigua* Desm., 1849 (mitosporic fungi)	-	PPIN, 2008	stems (PPIN, 2008); leaves, roots, stems (CPC, 2007)	no	yes (Farr et al, 2008; Teng, 1940)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Phoma macrostoma Mont., 1845 (mitosporic fungi)	-	Farr et al, 1989; Farr et al, 2007	fruit rot (Farr et al, 1989; Farr et al, 2007)	yes (Farr et al, 1989; Farr et al, 2007)	yes (Zhuang, 2005; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Phoma pomorum Thüm., 1879 (mitosporic fungi)	blister disease	Farr et al, 1989; Atkinson, 1971	wood, fruit (Atkinson, 1971); leaves (Farr et al, 1989; Morgan-Jones, 1967); leaves (Morgan-Jones, 1967); branches (Fazli and Razdan, 1991)	yes (Atkinson, 1971)	yes (Tai, 1979; Cui et al, 1994)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Phomopsis fukushii Endŏ and Tanaka, 1927 (mitosporic fungi)	Japanese pear canker	Zhang and Huang, 1990; Fukutomi et al, 1991	bark (Fukutomi et al, 1991); fruit (Nasu, 2005); stems, branches (Endo, 1927)	yes (Nasu, 2005; Nasu et al, 1987)	yes (Zhang and Huang, 1990; Zhuang, 2005)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	yes
Phomopsis viticola (Sacc.) Sacc., 1915 (mitosporic fungi)	dead arm fungus	PPIN, 2008; Anon., 2003	buds, twigs (PPIN, 2008); leaves, shoots (Rawnsley et al, 2006); canes, leaves, flowers, rachis and fruit (Savocchia et al, 2007)	yes (grapes (Savocchia et al, 2007))	yes (Farr et al, 2008; Mu and Liu, 1987)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no

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Phyllachora pomigena (Schwein.) Sacc., 1883 (Ascomycota: Ascomycetes: Phyllachorales: Phyllachoraceae)	sooty blotch	Jones and Aldwinckle, 1990; Farr et al, 1989	fruit (Jones and Aldwinckle, 1990); twigs, fruit (Atkinson, 1971)	yes (Jones and Aldwinckle, 1990)	yes (Farr et al, 2007; Tai, 1979)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Phyllactinia guttata (Wallr.) Lév., 1851 (Ascomycota: Ascomycetes: Erysiphales: Erysiphaceae)	powdery mildew	Farr et al, 2007; CPC, 2007	leaves (CPC, 2007); leaves, petioles, pedicles (Kurt and Soylu, 2001)	no	yes (Teng, 1996; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Phyllactinia mali (Duby) Braun, 1978 (Ascomycota: Ascomycetes: Erysiphales: Erysiphaceae)	powdery mildew of pear	Farr et al, 2007; Heluta and Minter, 1998	leaves (Heluta and Minter, 1998)	no	yes (Heluta and Minter, 1998; CPC, 2007)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no
Phyllactinia pyri (Castagne) Homma, 1937 (Ascomycota: Ascomycetes: Erysiphales: Erysiphaceae)	powdery mildew of pear	Farr et al, 2007; Tai, 1979	leaves (CPC, 2007; Liu and Gao, 1997)	no	yes (Tai, 1979; Zhuang, 2005)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no
Phyllosticta solitaria Ellis and Everh., 1895 (mitosporic fungi)	fruit blotch	Tai, 1979; Farr et al, 1989	leaves, twigs, fruit (Farr et al, 2007; CPC, 2007); fruit (Biggs, 1995)	yes (all hosts (Farr et al, 2008), apple (Biggs, 1995))	yes (Tai, 1979; Zhuang, 2005)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no*
Phymatotrichopsis omnivora (Duggar) Hennebert, 1973 (Basidiomycota: Basidiomycetes: Stereales: Sistotremataceae)	Phymatotri-chum root rot	Farr et al, 1989; CPC, 2007	root rot (Farr et al, 1989; Farr et al, 2007); roots (Jones and Aldwinckle, 1990)	no	yes (Farr et al, 2008)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no
Phytophthora cactorum (Lebert and Cohn) Schröt., 1886 (Oomycota: Pythiales: Pythiaceae)	apple collar rot	Jones and Aldwinckle, 1990; Pennycook, 1989	collar and fruit rot (Farr et al, 1989); roots, wood, fruit (PPIN, 2008); fruit (Jones and Aldwinckle, 1990)	yes (CPC, 2007; Jones and Aldwinckle, 1990)	yes (CPC, 2007; Tai, 1979)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Phytophthora cinnamomi Rands, 1922 (Oomycota: Pythiales: Pythiaceae)	stripe canker of cinnamon	Farr et al, 2007; Farr et al, 1989	stems, roots (CPC, 2007)	no	yes (CPC, 2007; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Phytophthora citricola Sawada, 1927 (Oomycota: Pythiales: Pythiaceae)	black hop root rot	Farr et al, 2007; PPIN, 2008	roots (PPIN, 2008); roots, fruit, bark (Farr et al, 2008); roots soil (Waterhouse and Waterston, 1966)	yes (guava (Farr et al, 2008))	yes (CPC, 2007; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no

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Phytophthora citrophthora (Sm. and Sm.) Leonian, 1906 (Oomycota: Pythiales: Pythiaceae)	brown rot of citrus fruit	Waterhouse and Waterston, 1964; Farr et al, 1989	trunk and crown canker, fruit rot, leaf and shoot blight, root rot (Waterhouse and Waterston, 1964)	yes (citrus (Waterhouse and Waterston, 1964))	yes (CPC, 2007; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Phytophthora cryptogea Pethybr. and Laff., 1919 (Oomycota: Pythiales: Pythiaceae)	tomato foot rot	Farr et al, 2007; McIntosh, 1964	collar, crown (PPIN, 2008); roots (McIntosh, 1964)	no	yes (CPC, 2007; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Phytophthora megasperma Drechsler, 1931 (Oomycota: Pythiales: Pythiaceae)	root rot	Farr et al, 1989; McIntosh, 1964	crown and root rot (Farr et al, 1989; Farr et al, 2007); roots (McIntosh, 1964)	no	yes (CPC, 2007)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Phytophthora nicotianae Breda de Haan, 1896 (Oomycota: Pythiales: Pythiaceae)	black shank	Farr et al, 2007; Farr et al, 1989	roots, stems, trunk, leaves, fruit, pods (Farr et al, 2008)	yes (all hosts (Farr et al, 2008))	yes (CPC, 2007; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Pleospora allii (anamorph *Stemphylium vesicarium*) (Rabenh.) Ces. and De Not., 1863 (Ascomycota: Ascomycetes: Dothideales: Pleosporaceae)	onion leaf blight	Antoniacci et al, 2006; Pattori et al, 2006	fruit, storage rot (Antoniacci et al, 2006)	yes (CPC, 2007; Antoniacci et al, 2006)	yes (CPC, 2007; CABI, 2006b)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Pleospora herbarum (anamorph *Stemphylium herbarum*) (Fr.) Rabenh., 1857 (Ascomycota: Ascomycetes: Dothideales: Pleosporaceae)	leaf blight of onion	Farr et al, 2007; Farr et al, 1989	storage rot (Farr et al, 1989; Farr et al, 2007)	yes (Farr et al, 2007; Farr et al, 1989)	yes (CPC, 2007; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Pleospora tarda (anamorph *Stemphylium botryosum*) Simmons, 1986 (Ascomycota: Ascomycetes: Dothideales: Pleosporaceae)	black mould	Farr et al, 2007; Farr et al, 1989	fruit (Geweely and Nawar, 2006)	yes (Geweely and Nawar, 2006)	yes (Zhuang, 2005; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Podosphaera clandestina (Wallr.) Lév., 1851 (Ascomycota: Ascomycetes: Erysiphales: Erysiphaceae)	powdery mildew	Khairi and Preece, 1975; Farr et al, 1989	buds, soft shoots, fruit (Khairi and Preece, 1975)	yes (hawthorne (Khairi and Preece, 1975))	yes (Farr et al, 2007; Li et al, 1999b)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Podosphaera leucotricha (Ellis and Everh.) Salmon, 1900 (Ascomycota: Ascomycetes: Erysiphales: Erysiphaceae)	powdery mildew of apple	White et al, 1990; Wauchope, 1965	leaves, buds, shoots, fruit (Atkinson, 1971); fruit, leaves (PPIN, 2008)	yes (CPC, 2007; Atkinson, 1971)	yes (Zhang and Huang, 1990; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Podosphaera macularis (Wallr.) Braun and Takam., 2000 (Ascomycota: Ascomycetes: Erysiphales: Erysiphaceae)	powdery mildew	Farr et al, 2007; Farr et al, 1989	inflorescence, leaves (CPC, 2007)	no	yes (CAB International, 2001c, CPC, 2007)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no

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Polyporus leptocephalus (Jacq.) Fr., 1821 (Basidiomycota: Basidiomycetes: Poriales: Polyporaceae)	wood-rotting fungus	Farr et al, 2007	trunks (IndexFungorum, 2008)	no	yes (Zhuang, 2005; Farr et al, 2008)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Polyporus squamosus (Huds.) Fr., 1821 (Basidiomycota: Basidiomycetes: Poriales: Polyporaceae)	-	Farr et al, 2007; Farr et al, 1989	living wood (Huang and Dai, 2005); wood rot (Beg and Ahmad, 1974)	no	yes (Zhuang, 2005; Bau et al, 2007)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Polyporus tubaeformis (Karst.) Ryvarden and Gilb., 1993 (Basidiomycota: Basidiomycetes: Poriales: Polyporaceae)	wood-rotting fungus	Farr et al, 2007	wood (Dai, 1996)	no	yes (Dai and Penttila, 2006)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Polystigmina rubra (Desm.) Sacc., 1884 (mitosporic fungi)	-	Farr et al, 2007; Tai, 1979	leaves (Teng, 1996)	no	yes (Zhuang, 2005; Teng, 1996)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Postia tephroleuca (Fr.) Jülich, 1982 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	wood decay fungus	Farr et al, 2007; Farr et al, 1989	wood (Tiwari and Harsh, 2005)	no	yes (Dai and Penttila, 2006; Dai et al, 2004b)	yes (Landcare NZFUNGI, 2008; Pennycook and Galloway, 2004)	no
Pseudocercospora mali (Ellis and Everh.) Deighton, 1976 (mitosporic fungi)	gray leaf spot	Braun and Crous, 2003; Wang et al, 2002	leaf spot (Farr et al, 2007; Wang et al, 2002)	no	yes (Braun and Crous, 2003; Wang et al, 2002)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Pseudocercospora pyricola (Sawada) Yen, 1981 (mitosporic fungi)	leaf spot	Tai, 1979; Braun and Crous, 2003	leaves (Guseinov, 1969)	no	yes (Tai, 1979; Braun and Crous, 2003)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Pulcherricium caeruleum (Lam.) Parmasto, 1968 (Basidiomycota: Basidiomycetes: Polyporales: Corticiaceae)	-	Farr et al, 2007	fallen twigs (Zhuang, 2005); wood (Hallenberg and Kuffer, 2001)	no	yes (Zhuang, 2005; Bau et al, 2007)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no

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Pycnoporus sanguineus (L.) Murrill, 1904 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	-	Farr et al, 2007	rotten wood, living stems (Zhuang, 2005); fallen trunk (Huang and Dai, 2005)	no	yes (Huang and Dai, 2005; Zhuang, 2005)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Pythium debaryanum Hesse, 1874 (Oomycota: Pythiales: Pythiaceae)	damping-off	Farr et al, 2007; Farr et al, 1989	root rot (Sprague, 1957; Farr et al, 2008); eggplant fruit rot (Roy, 1997); roots (CPC, 2007)	yes (eggplant (Roy, 1997))	yes (CPC, 2007; Zhang and Huang, 1990)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no*
Pythium irregulare Buisman, 1927 (Oomycota: Pythiales: Pythiaceae)	dieback of carrot	Farr et al, 2007	in soil (Zhuang, 2005); roots (Braun, 1995)	no	yes (CPC, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Pythium oligandrum Drechsler, 1930 (Oomycota: Pythiales: Pythiaceae)	myco-parasite of Pythium spp.	Farr et al, 2007	in soil (Zhuang, 2005)	no	yes (CPC, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Pythium pulchrum Minden, 1916 (Oomycota: Pythiales: Pythiaceae)	root rot	Farr et al, 2007; Farr et al, 1989	in soil (Zhuang, 2005)	no	yes (Zhuang, 2005; Yu, 1987)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Pythium spinosum Sawada, 1926 (Oomycota: Pythiales: Pythiaceae)	root rot of ornamentals	Farr et al, 2007	in soil (Zhuang, 2005)	no	yes (CPC, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Pythium splendens Hans Braun, 1925 (Oomycota: Pythiales: Pythiaceae)	blast of oil palm	Farr et al, 1989; CPC, 2007	seedling damping-off and fruit rot in cucumber (Chen et al, 1998)	yes (cucumber (Chen et al, 1998))	yes (CPC, 2007; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Pythium ultimum Trow, 1901 (Oomycota: Pythiales: Pythiaceae)	black-leg of seedlings	Farr et al, 2007; Farr et al, 1989	postharvest fruit rot in apples (Patel, 1984)	yes (apples (Patel, 1984))	yes (CPC, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Pythium vexans de Bary, 1876 (Oomycota: Pythiales: Pythiaceae)	damping off	van der Plaats-Niterinck, 1981; Farr et al, 1989	soil (Zhuang, 2005); bulbs, roots (CPC, 2007)	no	yes (CPC, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; Falloon, 1985)	no
Rhizopus stolonifer (Ehrenb.) Vuill., 1902 (Zygomycota: Zygomycetes: Mucorales: Mucoraceae)	black mould	Pennycook, 1989; Farr et al, 1989	fruit (PPIN, 2008; Jones and Aldwinckle, 1990)	yes (PPIN, 2008; Jones and Aldwinckle, 1990)	yes (Zhang and Huang, 1990; Teng, 1996)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no

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Rhytidhysteron rufulum (Spreng.) Speg., 1920 (Ascomycota: Ascomycetes: Patellariales: Patellariaceae)	-	Farr et al, 1989; Farr et al, 2007	dead branches (Farr et al, 1989); wood of dicotyledonous plants (Farr et al, 2007)	no	yes (Zhuang, 2005; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Rosellinia aquila (Fr.) Ces. and De Not., 1844 (Ascomycota: Ascomycetes: Xylariales: Xylariaceae)	root rot	Farr et al, 2007; Farr et al, 1989	twigs (Teng, 1996; Zhuang, 2005); branches (Kwasna and Akomy, 2006)	no	yes (Teng, 1996; Zhuang, 2005)	no (not recorded in: Pennycook, 1989)	no
Rosellinia necatrix (anamorph *Dematophora necatrix*) Berl. ex Prill., 1904 (Ascomycota: Ascomycetes: Xylariales: Xylariaceae)	demato-phora root rot	Farr et al, 1989; Pennycook, 1989	root rot (Farr et al, 1989; Jones and Aldwinckle, 1990); roots (Atkinson, 1971); stump (Teng, 1996)	no	yes (Teng, 1996; Zhang and Huang, 1990)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; CAB International, 1976c)	no
Schizophyllum commune Fr., 1815 (Basidiomycota: Basidiomycetes: Schizophyllales: Schizophyllaceae)	-	Farr et al, 2007; Farr et al, 1989	trunk rot (Farr et al, 1989); dead wood (Teng, 1996); rotten wood (Zhuang, 2005)	no	yes (Teng, 1996; Zhuang, 2005; Bau et al, 2007)	yes (Pennycook, 1989; Landcare NZFUNGI, 2007; PPIN, 2008)	no
Schizothyrium pomi (anamorph *Zygophiala jamaicensis*) (Mont. and Fr.) Arx, 1959 (Ascomycota: Ascomycetes: Dothideales: Schizothyriaceae)	fly speck	Farr et al, 1989; CPC, 2007	fly speck (Farr et al, 1989; Farr et al, 2007); fruit (Jones and Aldwinckle, 1990)	yes (Jones and Aldwinckle, 1990)	yes (CPC, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; Dingley, 1969)	no
Sclerotinia sclerotiorum (Lib.) de Bary, 1884 (Ascomycota: Ascomycetes: Helotiales: Sclerotiniaceae)	cottony soft rot	Pennycook, 1989; Farr et al, 1989	fruit (Farr et al, 2007; PPIN, 2008)	yes (PPIN, 2008)	yes (Teng, 1996; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Seimatosporium caudatum (Preuss) Shoemaker, 1964 (mitosporic fungi)	stem spot	Farr et al, 2007; Farr et al, 1989	twigs and branches (Farr et al, 2008); stems (Christoff and Christova, 1936)	no	yes (Zhuang, 2005; Farr et al, 2008)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Seimatosporium rhododendri (Schwein.) Piroz. and Shoemaker, 1970 (mitosporic fungi)	leaf spot	Farr et al, 2007; Farr et al, 1989	leaf spot (Farr et al, 1989)	no	yes (Farr et al, 2008)	no (not recorded in: Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Septobasidium pedicellatum (Schwein.) Pat., 1892 (Basidiomycota: Teliomycetes: Septobasidiales: Septobasidiaceae)	felt fungus	Orton and Wood, 1924	canker (Orton and Wood, 1924); living branches and trunks (Teng, 1996)	no	yes (Teng, 1996; Zhang et al, 1996)	no (not recorded in: Pennycook, 1989; PPIN, 2008; Landcare NZFUNGI, 2008)	no

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Septobasidium tanakae (Miyabe) Boedijn and Steinm., 1931 (Basidiomycota: Teliomycetes: Septobasidiales: Septobasidiaceae)	felt fungus	Farr et al, 2007; Tai, 1979	other *Septobasidium* spp. are found on trunks, branches and twigs.	no	yes (Tai, 1979; Zhang and Huang, 1990)	no (not recorded in: Pennycook, 1989; PPIN, 2008; Landcare, 2008)	no
Sphaerulina rehmiana (anamorph *Septoria rosae*) Jaap, 1910 (Ascomycota: Ascomycetes: Dothideales: Mycosphaerellaceae)	septoria leaf spot	Farr et al, 2007	leaves (Farr et al, 2008); leaves, bark (Boerema, 1963)	no	yes (Zhuang, 2005; Farr et al, 2008)	no (not recorded in: Pennycook, 1989; PPIN, 2008; Landcare, 2008)	no
Stachybotrys chartarum (Ehrenb.) Hughes, 1958 (mitosporic fungi)	grain mould	Farr et al, 2007	wood (Farr et al, 2008)	no	yes (Liang and Bai, 1988; Chen et al, 2004)	yes (Landcare NZFUNGI, 2008)	no
Stagonospora mali Delacr., 1890 (mitosporic fungi)	-	Farr et al, 2007; Tai, 1979	dry leaves (Saccardo, 1892b)	no	yes (Farr et al, 2007; Tai, 1979)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no
Stereum hirsutum (Willd.) Pers., 1800 (Basidiomycota: Basidiomycetes: Russulales: Stereaceae)	-	Farr et al, 2007; Farr et al, 1989	trunk rot (Farr et al, 1989; Farr et al, 2007); dead wood (Teng, 1996)	no	yes (Teng, 1996; Zhuang, 2005; Bau et al, 2007)	yes (Landcare NZFUNGI, 2008; PPIN, 2008; Pennycook, 1989)	no
Stigmina carpophila (Lév.) Ellis, 1959 (mitosporic fungi)	gumspot of stone fruit	Farr et al, 2007; Kirk, 1999	leaves, twigs (Kirk, 1999)	no	yes (CPC, 2007; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; PPIN, 2008)	no
Taphrina bullata (Berk. and Broome) Tul., 1866 (Ascomycota: Ascomycetes: Taphrinales: Taphrinaceae)	leaf blister	Farr et al, 1989; Tai, 1979	leaves (Farr et al, 1989; Farr et al, 2007)	no	yes (Farr et al, 2007; Tai, 1979)	no (not recorded in: Pennycook, 1989; Landcare, 2008)	no
Thanatephorus cucumeris (anamorph *Rhizoctonia solani*) (Frank) Donk, 1956 (Basidiomycota: Basidiomycetes: Ceratobasidiales: Ceratobasidiaceae)	-	Farr et al, 2007; Farr et al, 1989	roots (Teng, 1996); stem base, leaves, fruit of low-growing plants e.g. cucumber (CPC, 2007)	yes (cucumber (CPC, 2007))	yes (Zhuang, 2005; Teng, 1996)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989)	no
Trametes hirsuta (Wulfen) Pilát, 1939 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	-	Farr et al, 2007; Farr et al, 1989	rotten wood and twigs (Zhuang, 2005); rotten wood (Huang and Dai, 2005)	no	yes (Teng, 1996; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; PPIN, 2008)	no

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Trametes versicolor (L.) Lloyd, 1921 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	-	Pennycook, 1989; Farr et al, 1989	wood (Farr et al, 1989; PPIN, 2008); fallen trunk (Huang and Dai, 2005)	no	yes (Zhuang, 2005; Bau et al, 2007)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Tranzschelia pruni-spinosae (Pers.) Dietel, 1922 (Basidiomycota: Urediniomycetes: Uredinales: Uropyxidaceae)	leaf rust	Farr et al, 2007	leaves (Teng, 1996)	no	yes (Teng, 1996; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Jafar, 1958)	no
Trichaptum biforme (Fr.) Ryvarden, 1972 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	white rot	Farr et al, 1989; Shaw, 1973	wood (Fukasawa, 2005)	no	yes (Zhuang, 2005; Bau et al, 2007)	no (not recorded in: Pennycook, 1989; Landcare, 2008; PPIN, 2008)	no
Trichothecium roseum (Pers.) Link, 1809 (mitosporic fungi)	pink rot	Farr et al, 1989; Pennycook, 1989	stored fruit decay (Wan, 2000; Xu et al, 1999b); fruit (Jones and Aldwinckle, 1990)	yes (Pandey et al, 1985; Xu et al, 1999b)	yes (Zhuang, 2005; AQSIQ, 2007)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Truncatella hartigii (Tubeuf) Steyaert, 1949 (mitosporic fungi)	-	Farr et al, 2007; Farr et al, 1989	stems, branches, or twigs (Farr et al, 2007); leaves (Bhardwaj and Agarwala, 1985)	no	yes (Farr et al, 2008)	no (not recorded in: Landcare NZFUNGI, 2008; PPIN, 2008; Pennycook, 1989)	no
Truncospora truncatospora (Lloyd) Ito, 1955 (Basidiomycota: Basidiomycetes: Poriales: Coriolaceae)	-	Farr et al, 2007; Tai, 1979	Likely to be a wood-rotting fungus (one synonym is *Trametes truncatospora*).	no	yes (Farr et al, 2007; Tai, 1979)	no (not recorded in: Landcare NZFUNGI, 2008; PPIN, 2008; Pennycook, 1989)	no
Tryblidiella fusca (Ellis and Everh.) Rehm, 1900 (Ascomycota: Ascomycetes: Patellariales: Patellariaceae)	-	Farr et al, 2007	wood (Farr et al, 2007)	no	yes (Farr et al, 2008)	no (not recorded in: Landcare NZFUNGI, 2008; PPIN, 2008; Pennycook, 1989)	no
Tuberculina persicina (Ditmar) Sacc., 1881 (mitosporic fungi)	-	Landcare NZFUNGI, 2007	*Tuberculina persicina* is a mycoparasite of *Gymnosporangium sabinae*; *Pyrus* is the secondary host.	yes (mycoparasite)	yes (Huang et al, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook and Galloway, 2004)	no

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Valsa ambiens (anamorph *Cytospora leucosperma*) (Pers.) Fr., 1849 (Ascomycota: Ascomycetes: Diaporthales: Valsaceae)	valsa canker	Zhang and Huang, 1990; She et al, 2005	fruit (Tewari et al, 1987); bark (Zhang, 2003); bark cankers (Kowalski and Materniak, 2007)	yes (Tewari et al, 1987)	yes (Teng, 1996; Zhang and Huang, 1990; AQSIQ, 2007)	yes (Pennycook, 1989; PPIN, 2008)	no
Valsa ceratosperma (anamorph *Cytospora sacculus*) (Tode) Maire, 1937 (Ascomycota: Ascomycetes: Diaporthales: Valsaceae)	valsa canker	CPC, 2007; Farr et al, 1989	bark (Collina et al, 2006); stem and fruit (Montuschi and Collina, 2003); bark of apple trees (Jones and Aldwinckle, 1990)	yes (Montuschi and Collina, 2003)	yes (CPC, 2007; Zhang and Huang, 1990)	yes (PPIN, 2008; Landcare NZFUNGI, 2008)	no
Valsa leucostomoides Peck, 1885 (Ascomycota: Ascomycetes: Diaporthales: Valsaceae)	-	Farr et al, 2007	bark, twigs, branches (Farr et al, 2008; Hayova and Minter, 1998b)	no	yes (Farr et al, 2008)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no
Valsaria insitiva (Tode) Ces. and De Not., 1863 (Ascomycota: Ascomycetes: Dothideales: Venturiaceae)	-	Farr et al, 2007	twigs (Zhuang, 2005)	no	yes (Zhuang, 2005)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no
Venturia carpophila (anamorph *Fusicladium carpophilum*) Fisher, 1961 (Ascomycota: Ascomycetes: Dothideales: Venturiaceae)	almond scab	CPC, 2007 Schubert et al, 2003 state that records on hosts other than *Prunus* spp. are doubtful.	Living leaves, twigs, fruit (Farr et al, 2008; Schubert et al, 2003). *Fusicladium* sp. are found on fruit of Rosaceae (Beck et al, 2005)	no	yes (Zhuang, 2005; Farr et al, 2008)	yes (Landcare NZFUNGI, 2008; Dingley, 1969; PPIN, 2008)	no
Venturia inaequalis (anamorph *Fusicladium pomi*) (Cooke) Winter, 1897 (Ascomycota: Ascomycetes: Dothideales: Venturiaceae)	apple scab	Sivanesan and Waller, 1974; Farr et al, 1989	shoots, buds, blossoms, leaves, fruit (Sivanesan and Waller, 1974)	yes (apple (CPC, 2007))	yes (CPC, 2007; Zhuang, 2005)	yes (Landcare NZFUNGI, 2008; Pennycook, 1989; PPIN, 2008)	no
Venturia nashicola (anamorph *Fusicladium nashicola*) S.Tanaka and S. Yamam, 1964 (Ascomycota: Ascomycetes: Dothideales: Venturiaceae)	Japanese pear scab	Li et al, 2007a; Brewer et al, 2005	leaves (Farr et al, 2007; Li et al, 2007a; Schubert et al, 2003); fruit (Brewer et al, 2005; Li et al, 2007a)	yes (Li et al, 2007a)	yes (Farr et al, 2007; Wei and Gao, 2002)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	yes

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Venturia pyrina (anamorph *Fusicladium pyrorum*) Aderh., 1896 (Ascomycota: Ascomycetes: Dothideales: Venturiaceae)	pear scab	Zhang and Huang, 1990; Pennycook, 1989	fruit, leaves, shoots (Jones and Aldwinckle, 1990; PPIN, 2008); leaves (Chavez-Alfaro et al, 1995)	yes (Jones and Aldwinckle, 1990; PPIN, 2008)	yes (Zhang and Huang, 1990; Wang, 1997)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	no
Verticillium dahliae Kleb., 1913 (mitosporic fungi)	verticillium wilt	Farr et al, 1989; White et al, 1990	seedlings (PPIN, 2008); roots, trunks, branches, twigs (White et al, 1990)	no	yes (Zhuang, 2005)	yes (Landcare NZFUNGI, 2007; Pennycook, 1989; PPIN, 2008)	no
Xylaria carpophila (Pers.) Fr., 1849 (Ascomycota: Ascomycetes: Xylariales: Xylariaceae)	beechmast candlesnuff	Farr et al, 2007; Paul et al, 1990	wood, fallen trees, 'fruit' of *Fagus* spp. (Farr et al, 2008); fallen nuts (Teng, 1996)	no	yes (Teng, 1996; Farr et al, 2008)	no (not recorded in: Pennycook, 1989; Landcare NZFUNGI, 2008; PPIN, 2008)	no*
INSECTA							
COLEOPTERA							
Aeolesthes holosericea (Fabricius, 1787) (Coleoptera: Cerambycidae)	apple stem borer	Sharma and Attri, 1969	stems - wood borer (Sharma and Attri, 1969)	no	yes (Qian, 1985)	no (genus not recorded in Leschen et al, (2003))	no
Agrilus mali Matsumura (Coleoptera: Buprestidae)	apple wood borer	Biosecurity Australia, 2005	bark, leaves, stems and wood of apple (CPC, 2007)	no	yes (Muramatsu, 1924; CPC, 2007)	no (genus not recorded in Leschen et al, (2003))	no
Anomala corpulenta Motschulsky (Coleoptera: Scarabaeidae)	copper green chafer	AQSIQ, 2007	Like other members of this genus, the larvae are likely to be soilborne, damaging roots, and the adults found on leaves.	no	yes (AQSIQ, 2007; CPC, 2007)	no (genus not recorded in Leschen et al, (2003))	no
Anoplophora chinensis (Forster) (Coleoptera: Cerambycidae)	black and white citrus longhorn	CPC, 2007	adults on leaves, petioles and bark, larvae tunnel into trunk (CPC, 2007)	no	yes (CPC, 2007; CAB International, 1999a)	no (genus not recorded in Leschen et al, (2003))	no
Anoplophora glabripennis (Motschulsky) (Coleoptera: Cerambycidae)	glabrous spotted willow borer	AQSIQ, 2007	wood borer (MacLeod et al, 2002)	no	yes (Wang and Zhang, 1993; CPC, 2007)	no (genus not recorded in Leschen et al, (2003))	no

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Anoplophora nobilis Ganglbauer (Coleoptera: Cerambycidae)	yellow-spotted longicorn	Shang et al, 2000	stem borer (Zhou et al, 1981)	no	yes (Shang et al, 2000; Wang and Zhang, 1993)	no (genus not recorded in Leschen et al, (2003))	no
Anthonomus pomorum (Linnaeus, 1758) (Coleoptera: Curculionidae)	apple-blossom weevil	Hill, 1987; CPC, 2007	larvae destroy flowers (Hill, 1987); new foliage, occasionally young fruit (CPC, 2007)	uncertain	yes (CPC, 2007; CAB International, 2002a)	no (genus not recorded in Leschen et al, (2003))	no*
Apriona germarii Hope (Coleoptera: Cerambycidae)	mulberry longicorn	AQSIQ, 2007; Gao and Zheng, 1998	shoots (Gao and Zheng, 1998); wood (Wang and Zhang, 1993)	no	yes (Wang and Zhang, 1993; Yang et al, 2005c)	no (genus not recorded in Leschen et al, (2003))	no
Arhopalus ferus (Mulsant) (Coleoptera: Cerambycidae)	burnt pine longhorn	PPIN, 2008	Most Cerambycidae larvae live and feed inside the stems and branches of trees and shrubs (Forchhammer and Wang, 1987). Apart from one PPIN record on pear fruit (PPIN, 2008), there is no indication that *Arhopalus ferus* infests fruit. It is likely that this was a transient association.	yes (PPIN, 2008)	yes (CPC, 2007)	yes (Hosking, 1970; Hosking and Bain, 1977; PPIN, 2008; genus is recorded in Leschen et al, 2003)	no
Aromia bungii Faldermann, 1835 (Coleoptera: Cerambycidae)	red-necked longicorn	AQSIQ, 2007	boring trunks (Liu et al, 1999)	no	yes (AQSIQ, 2007; Qian, 1989)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no
Asias halodendri (Pallas) (Coleoptera: Cerambycidae)	red-lined long-horned beetle	AQSIQ, 2007	Most Cerambycidae larvae live and feed inside the stems and branches of trees and shrubs (Forchhammer and Wang, 1987).	no	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no

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Bacchisa fortunei (Thomson) (Coleoptera: Cerambycidae)	pear borer	She et al, 2005	branches, trunks (She et al, 2005)	no	yes (Qian, 1989; CPC, 2007)	no (not recorded in: ESNZ, 1977; genus not recorded in Leschen et al, 2003)	no
Bacchisa guerryi (Pic) (Coleoptera: Cerambycidae)	tree borer	Yang et al, 1994	Most Cerambycidae larvae live and feed inside the stems and branches of trees and shrubs (Forchhammer and Wang, 1987).	no	yes (Yang et al, 1994)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no
Byctiscus betulae (Linnaeus) (Coleoptera: Curculionidae)	birch attlebaid	Smol'yannikov, 1979; Kovalenkov and Stolyarov, 2000	buds, leaves (Dobrovol'skii, 1950); leaves (de Tillesse et al, 2008)	no	yes (as *Cysticus betulae* (AQSIQ, 2007)	no (genus not recorded in Leschen et al, 2003)	no
Callidium sp. (Coleoptera: Cerambycidae)	-	AQSIQ, 2007	Most Cerambycidae larvae live and feed inside the stems and branches of trees and shrubs (Forchhammer and Wang, 1987)	no	yes (AQSIQ, 2007)	No (genus not recorded in Leschen et al, 2003)	no
Chrysobothris succedanea Saunders (Coleoptera: Buprestidae)	six-spotted buprestid	Biosecurity Australia, 2005	*Chrysobothris* spp. are borers of branches (Abaii, 2006)	no	yes (Yuan et al, 2007)	no (genus not recorded in Leschen et al, 2003)	no
Coccinella undecimpunctata L. (Coleoptera: Coccinellidae)	elevenspotted ladybird	PPIN, 2008	predator of insect plant pests (Abdel, 2006)	no	yes (Li et al, 2007b)	yes (PPIN, 2008; Scott and Emberson, 1999)	no
Cryptophagus sp. (Coleoptera: Cryptophagidae)	fungus beetle	MAFBNZ, 2009	fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	unknown (genus is recorded in Leschen et al, 2003)	no*
Harmonia axyridis (Pallas, 1773) (Coleoptera: Coccinellidae)	harlequin ladybird	CPC, 2007; MAFBNZ, 2009	fruit (CPC, 2007; MAFBNZ, 2009)	yes (CPC, 2007)	yes (CPC, 20079)	no (genus is recorded in Leschen et al, 2003)	yes
Holotrichia morosa Waterhouse, 1875 (Coleoptera: Scarabaeidae)	large black chafer	Okamoto, 1940	leaves (Okamoto, 1940)	no	yes (Chang et al, 1980; Tian and Hu, 1992)	no (genus not recorded in Leschen et al, 2003)	no

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Holotrichia parallela (Motschulsky) (Coleoptera: Scarabaeidae)	Asian cockchafer	AQSIQ, 2007	*Holotrichia* spp. larvae feed on roots, adults also feed on leaves (e.g. Kapadia et al, 2006)	unknown	yes (AQSIQ, 2007; CPC, 2007)	no (genus not recorded in Leschen et al, 2003)	no*
Holotrichia titanis Reitter (Coleoptera: Scarabaeidae)	brown chafer	AQIS, 1998	*Holotrichia* spp. larvae feed on roots, adults also feed on leaves (e.g. Kapadia et al, 2006)	unknown	yes (Ma et al, 2003; Leng et al, 1983)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no*
Hylurgus ligniperda Fabricius (Coleoptera: Scolytidae)	goldenhaired bark beetle	PPIN, 2008	fruit (PPIN, 2008); bark (Reay and Brownbridge, 2007)	yes (PPIN, 2008)	yes (CPC, 2007; SPFNIC, 2001)	yes (Reay and Brownbridge, 2007; PPIN, 2008)	no
Lampra bellula Lewis (Coleoptera: Buprestidae)	jewel beetle	AQSIQ, 2007	larvae of *Lampra* spp. bore trunk under bark (Hill, 1987)	no	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no
Lampra limbata Gebler (Coleoptera: Buprestidae)	golden jewel beetle	AQSIQ, 2007	larvae of *Lampra* spp. bore trunk under bark (Hill, 1987)	no	yes (AQSIQ, 2007; Beijing Insects, 2008)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no
Maladera orientalis (Motschulsky) (Coleoptera: Scarabaeidae)	smaller velvet chafer	AQSIQ, 2007	buds, new leaves, flowers (Wang and Meng, 2004; Tsai and Hwang, 1963)	no	yes (Wang and Meng, 2004; CPC, 2007)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no
Metabolus flavescens Brenske (Coleoptera: Scarabaeidae)	-	Yang, 1991	roots (Guo and Wen, 1988)	no	yes (CPC, 2007; Yang, 1991)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no
Oxycetonia jucunda Faldermann (Coleoptera: Scarabaeidae)	citrus flower chafer	AQSIQ, 2007	flowers of citrus (Yokomizo and Nagano, 1982)	no	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no
Popillia quadriguttata Fabricius (Coleoptera: Scarabaeidae)	Chinese rose beetle	AQSIQ, 2007	a turfgrass pest (Lee et al, 2005)	no	yes (AQSIQ, 2007)	no (genus not recorded in: Leschen et al, 2003)	no
Potosia brevitarsis Lewis, 1879 (Coleoptera: Scarabaeidae)	white spotted flower chafer	AQSIQ, 2007	flowers (Hong and Liu, 2004)	no	yes (AQSIQ, 2007)	no (genus not recorded in: Leschen et al, 2003)	no
Proagopertha lucidula Faulderman, 1835 (Coleoptera: Scarabaeidae)	Lucidula chafer	Li, 1981; Lee et al, 1973	flower buds (Li et al, 2005b)	no	yes (AQSIQ, 2007; Lee et al, 1973)	no (genus not recorded in Leschen et al, 2003)	no

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Rhynchites auratus (Scopoli, 1763) (Coleoptera: Attelabidae)	pear attelabid	Bashkatova et al, 1983	fruit, leaves (Dezianian, 2005); buds, blossoms, shoots, leaves, fruit (Thiem, 1938)	yes (cherry (Dezianian, 2005), cherry (Thiem, 1938))	yes (Yang et al, 2005b; Wang et al, 1998a)	no (genus not recorded in Leschen et al, 2003; Kuschel, 2003 – no members of the family in NZ)	yes
Rhynchites coreanus Kono, 1926 (Coleoptera: Attelabidae)	pear curculio	AQSIQ, 2007; Kondo and Miyahara, 1930	the larvae of other species of *Rhynchites* are known to burrow into the fruit of various host plants (Luo et al, 1998).	yes (*Rhynchites* sp. - "fruit" (Luo et al, 1998))	yes (AQSIQ, 2007; Kondo and Miyahara, 1930)	no (genus not recorded in Leschen et al, 2003; Kuschel, 2003 – no members of the family in NZ)	no*
Rhynchites foveipennis Fairmaire, 1888 (Coleoptera: Attelabidae)	Korean pear weevil	Biosecurity Australia, 2005; Chinese Ministry of Agriculture, Pers comm, 1991	larvae of the related *Rhynchites auratus* bore into cherry fruit (Dezianian, 2005)	yes (cherry fruit (Dezianian, 2005) (*Rhynchites auratus*))	yes (Bai and Chen, 1991; Gao et al, 1992)	no (genus not recorded in Leschen et al, 2003; Kuschel, 2003 – no members of the family in NZ)	no*
Rhynchites heros Roelofs, 1874 (Coleoptera: Attelabidae)	Japanese pear weevil	Tseng and Ho, 1937; Yago, 1933	fruit (Tseng and Ho, 1937)	yes (Tseng and Ho, 1937)	yes (Tseng and Ho, 1937; Yu, 1936)	no (genus not recorded in Leschen et al, 2003; Klimaszewski and Watt, 1997 – no members of the family in NZ)	yes
Scolytus rugulosus (Mueller, 1818) (Coleoptera: Scolytidae)	shothole borer	CPC, 2007	branches, stems (Yang et al, 2005b)	no	yes (Yang et al, 2005b)	no (not recorded in: Brockerhoff et al, 2003; CPC, 2007; PPIN, 2008)	no
Scolytus schevyrewi Semenov (Coleoptera: Scolytidae)	banded elm bark beetle	CPC, 2007	stems (Jacobi et al, 2007)	no	yes (CPC, 2007; USDA, 2004)	no (not recorded in: Brockerhoff, 2003; PPIN, 2008)	no
Trichoferus campestris (Faldermann, 1835) (Coleoptera: Cerambycidae)	-	CPC, 2007	wood (Krivosheina and Tokgaev, 1985)	no	yes (CPC, 2007; Zhan, 1984)	no (not recorded in: PPIN, 2008; genus not recorded in Leschen et al, 2003)	no
Typhaea stercorea Linnaeus (Coleoptera: Mycetophagidae)	hairy fungus beetle	PPIN, 2008	fruit (PPIN, 2008); associated with stored products (CPC, 2007)	yes (PPIN, 2008)	yes (CPC, 2007)	yes (Scott and Emberson, 1999; PPIN, 2008)	no

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Xyleborinus saxeseni (Ratzeburg, 1837) (Coleoptera: Scolytidae)	fruit-tree pinhole borer	CPC, 2007	roots (Batt, 2000); bark (Rupf, 1980)	no	yes (CPC, 2007; MSU, 2008a)	yes (Scott and Emberson, 1999; PPIN, 2008)	no
Xyleborus dispar (Fabricius, 1792) (Coleoptera: Scolytidae)	ambrosia beetle	CPC, 2007; Roediger, 1956	bark (Perkons and Kontrolevich, 1998)	no	yes (CPC, 2007; MSU, 2008b)	no (not recorded in: Brockerhoff, 2003; PPIN, 2008)	no
Xylotrupes gideon (Linnaeus, 1767) (Coleoptera: Scarabaeidae)	elephant beetle	Sirinthip and Black, 1987	bark (Sirinthip and Black, 1987); fruit (Rogers and Blair, 1983; Waite and Elder, 2005)	uncertain	yes (CAB International, 1985; CPC, 2007)	no (genus not recorded in Leschen et al, (2003); not recorded in PPIN, 2008)	no*
DIPTERA							
Bactrocera dorsalis (Hendel, 1912) (Diptera: Tephritidae)	Oriental fruit fly	CPC, 2007; White and Elson-Harris, 1992	fruit (White and Elson-Harris, 1992; Paramjit-Singh and Mann, 2003)	yes (CPC, 2007; Paramjit-Singh and Mann, 2003)	yes (CPC, 2007; White and Elson-Harris, 1992)	no (not recorded in: MacFarlane et al, 2000)	yes
Ceratitis capitata (Wiedemann, 1824) (Diptera: Tephritidae)	Mediterranean fruit fly	White and Elson-Harris, 1992; Segura et al, 2004	fruit (White and Elson-Harris, 1992); fruit (CPC, 2007)	yes (CPC, 2007; White and Elson-Harris, 1992)	yes (Lu et al, 2006; Cheng, 2003)	no (not recorded in: MacFarlane et al, 2000)	no*
Contarinia pyrivora (Riley, 1886) (Diptera: Cecidomyiidae)	pear midge	Maciesiak et al, 2003; Hill, 1987	flower buds (Maciesiak et al, 2003); fruit (Polesny, 1990; Hill, 1987)	yes (Hill, 1987; Polesny, 1990)	yes (Deng and Nan, 2001)	no (not recorded in: MacFarlane et al, 2000)	yes
Spilogona sp. (Diptera: Muscidae)	fly	MAFBNZ, 2009	fruit (MAFBNZ, 2007); flowers (Pont, 1993)	yes (MAFBNZ, 2007)	yes (MAFBNZ, 2009; Xu et al, 2005)	Unknown	no*
HEMIPTERA							
Adelphocoris lineolatus (Goeze, 1778) (Hemiptera: Miridae)	alfalfa plant bug	CPC, 2007	stems (CPC, 2007); buds, young leaves (Carli et al, 1987)	no	yes (CPC, 2007; Li et al, 2007c)	no (not recorded in Larivière and Larochelle, 2004)	no
Aleurocanthus spiniferus (Quaintance, 1903) (Hemiptera: Aleyrodidae)	orange spiny whitefly	Hill, 1987; CPC, 2007	leaves (Hill, 1987); leaves (Li, 1999); leaves, stems (CPC, 2007)	no	yes (CPC, 2007; CAB International, 1976a)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no

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Aleurocanthus woglumi Ashby, 1915 (Hemiptera: Aleyrodidae)	citrus whitefly	USDA whitefly database, 2008; CPC, 2007	leaves (CPC, 2007)	no	yes (Luo and Zhou, 2000; CAB International, 1976b)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no
Andaspis hawaiiensis (Maskell, 1895) (Hemiptera: Diaspididae)	burrowing scale	ScaleNet, 2007	burrows beneath the epidermis of the bark of their host (ScaleNet, 2007)	no	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	no
Anuraphis sp. (Hemiptera: Aphididae)	aphid	AQSIQ, 2007	Other *Anuraphis* spp. (e.g. *A. farfarae*) occur on the leaves (Blackman and Eastop, 2000)	no	yes (AQSIQ, 2007)	Unknown. Genus not recorded in Teulon et al, 2004	no
Aonidiella aurantii (Maskell, 1879) (Hemiptera: Diaspididae)	California red scale	ScaleNet, 2007	may infest all the above-ground parts of host plants (ScaleNet, 2008)	yes all hosts (ScaleNet, 2007)	yes (ScaleNet, 2007)	yes (Charles and Henderson, 2002)	no
Aonidiella orientalis (Newstead, 1894) (Hemiptera: Diaspididae)	Oriental scale	Rahman and Ansari, 1941	leaves (ScaleNet, 2007); leaves, but sometimes on branches, trunks, shoots and fruit (CPC, 2007)	uncertain (all hosts (CPC, 2007))	yes (ScaleNet, 2007; CPC, 2007)	no (not recorded in: Charles and Henderson, 2002PPIN, 2009)	no*
Aphanostigma iaksuiense (Kishida) (Hemiptera: Phylloxeridae)	powdery pear aphid	Tai et al, 2004; Chen and Wang, 2001	fruit, trunk and branches (Chen and Wang, 2001); fruit (Yoon and Lee, 1974)	yes (Yoon and Lee, 1974; Chen and Wang, 2001)	yes (AQSIQ, 2007; Tai et al, 2004)	no (not recorded in: PPIN, 2009; Charles, 1998)	yes
Aphis craccivora Koch, 1854 (Hemiptera: Aphididae)	cowpea aphid	Blackman and Eastop, 2000; Blackman and Eastop, 1994	; young leaves, shoots, flowers and immature seed pods (CPC, 2007)	no	yes (CPC, 2007; Gong et al, 1999)	yes (Teulon et al, 2004)	no
Aphis fabae Scopoli (Hemiptera: Aphididae)	black bean aphid	Blackman and Eastop, 2000	shoots (Blackman and Eastop, 2000); leaves (CPC, 2007)	no	yes (CPC, 2007; Liu et al, 2005)	no (not recorded in: Teulon et al, 2004; PPIN, 2009)	no
Aphis gossypii Glover, 1877 (Hemiptera: Aphididae)	melon aphid	Blackman and Eastop, 2000; Kuo et al, 2001	leaves, stems, inflorescence (CPC, 2007)	no	yes (Liu et al, 2007)	yes (Teulon et al, 2004)	no

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Aphis pomi de Greer (Hemiptera: Aphididae)	green apple aphid	Blackman and Eastop, 2000; Kuo et al, 2001	leaves, young growth (Blackman and Eastop, 2000); fruit (Beers et al, 1993)	yes	yes (Chai, 1998)	no (not recorded in Teulon et al, 2004)	yes
Aphis spiraecola Patch, 1914 (Hemiptera: Aphididae)	green citrus aphid	Blackman and Eastop, 1994	buds, shoots and leaves (CPC, 2007)	no	yes (Chen and Wong, 1998)	yes (Teulon et al, 2004)	no
Aspidiotus nerii Bouche, 1833 (Hemiptera: Diaspididae)	oleander scale	ScaleNet, 2007; CPC, 2007	fruit/pods, growing points, leaves, stems and whole plant (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (ScaleNet, 2007)	yes (Charles and Henderson, 2002)	no
Asterococcus muratae (Kuwana) (Hemiptera: Cerococcidae)	pit scale	ScaleNet, 2007	Other Cerococcidae are recorded from green branches (e.g. Regupathy, 1980)	no	yes (ScaleNet, 2007; Song et al, 1994b)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no
Aulacaspis rosae (Bouche, 1833) (Hemiptera: Diaspididae)	rose scale	ScaleNet, 2007	hibernates on the bark of host stems, near the roots (ScaleNet, 2008)	no	yes (ScaleNet, 2007; Gao, 1989)	yes (Charles and Henderson, 2002)	no
Aulacorthum magnoliae (Essig and Kuwana) (Hemiptera: Aphididae)	-	Blackman and Eastop, 2000; Blackman and Eastop, 1994	leaves (Blackman and Eastop, 2000)	no	yes (Blackman and Eastop, 2000; Zhang and Zhong, 1985)	no (not recorded in: Teulon et al, 2004; PPIN, 2009)	no
Aulacorthum solani (Kaltenbach, 1843) (Hemiptera: Aphididae)	glasshouse-potato aphid	PPIN, 2008	bulbs (Blackman and Eastop, 2000)	no	yes (Jiang et al, 2005; CPC, 2007)	yes (Teulon et al, 2004)	no
Brachycaudus amygdalinus (Schouteden, 1905) (Hemiptera: Aphididae)	leaf-curling almond aphid	CPC, 2007; Mustafa and Hamdan, 1989	leaves (Stroyan, 1980)	no	yes (CPC, 2007; Zhang et al, 1987)	no (not recorded in: Teulon et al, 2004)	no
Brachycaudus cardui (Linnaeus, 1758) (Hemiptera: Aphididae)	thistle aphid	Blackman and Eastop, 2000; Blackman and Eastop, 1994	leaves, stems, flowerheads (Blackman and Eastop, 2000)	no	yes (Blackman and Eastop, 2000)	no (not recorded in: Teulon et al, 2004)	no
Brachycaudus helichrysi (Kaltenbach, 1843) (Hemiptera: Aphididae)	leaf-curling plum aphid	Blackman and Eastop, 2000; Blackman and Eastop, 1994	leaves, stems, flowerheads (Blackman and Eastop, 2000); newly formed fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; Yang et al, 2005b)	yes (Teulon et al, 2004)	no*

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Cacopsylla chinensis (Yang and Li) (Hemiptera: Psyllidae)	pear psyllid	Yang and Li, 1981; Jiang et al, 2003	buds, flowers, young shoots, leaves (Jiang et al, 2003). Interceptions of unidentified psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009)	unknown	yes (AQSIQ, 2007; Yang and Li, 1981; Jiang et al, 2003)	no (not recorded in: PPIN, 2008; Charles 1998)	yes
Cacopsylla peregrina (Forster, 1848) (Hemiptera: Psyllidae)	hawthorn psyllid	Li, 1992	Psyllids are most often found on leaves, buds and young stems. Interceptions of unidentified psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009)	unknown	yes (Li, 1992)	no (not recorded in: PPIN, 2008; Charles 1998; Ferris and Klyver, 1932; Maskell 1890; Tuthill, 1952)	yes
Cacopsylla pyri (L.) (Hemiptera: Psyllidae)	pear psylla	Sigsgaard et al, 2006; Yang and Li, 1981	branches (Sigsgaard et al, 2006); leaves (Hill, 1987); bark, shoots, leaves (CPC, 2007). Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009)	unknown	yes (CPC, 2007; Deng and Nan, 2001)	no (not recorded in: PPIN, 2008; Ferris and Klyver, 1932; Maskell 1890; Tuthill, 1952)	yes
Cacopsylla pyricola (Förster, 1848) (Hemiptera: Psyllidae)	pear sucker	Horton et al, 2007; Hill, 1987	shoots (Horton et al, 2007); shoots, leaves, blossoms (Hill, 1987); leaves, buds, 'budsticks' (CPC, 2007). Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009)	unknown	yes (CPC, 2007; CAB International, 2005)	no (not recorded in: PPIN, 2008; Ferris and Klyver, 1932; Maskell 1890; Tuthill, 1952)	yes
Cacopsylla pyrisuga Förster, 1848 (Hemiptera: Psyllidae)	pear sucker	CPC, 2007; Burckhardt and Hodkinson, 1986	leaves, twigs (CPC, 2007). Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009)	unknown	yes (CPC, 2007)	no (not recorded in: PPIN, 2008; Ferris and Klyver, 1932; Maskell 1890; Tuthill, 1952)	yes

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Ceroplastes floridensis Comstock, 1881 (Hemiptera: Coccidae)	Florida wax scale	Ben-Dov, 1993; CPC, 2007	Infestations of *C. floridensis* occur on the foliage, stems and branches (CPC, 2007)	no	yes (Ben-Dov, 1993; ScaleNet, 2007)	no (not recorded in: Hodgson and Henderson, 2000; PPIN, 2009)	no
Ceroplastes japonicus Green (Hemiptera: Coccidae)	Japanese/tortoise/pink wax scale	ScaleNet, 2007; CPC, 2007	Infestations of *C. japonicus* occur on the foliage, stems and branches (CPC, 2007)	no	yes (AQSIQ, 2007; Ben-Dov, 1993)	no (not recorded in: Hodgson and Henderson, 2000; PPIN, 2009)	no
Ceroplastes pseudoceriferus Green (Hemiptera: Coccidae)	-	ScaleNet, 2007	Infests young flowers, older leaves, twigs in mango (Ali, 1980)	no	yes (ScaleNet, 2007; CPC, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; Hodgson and Henderson, 2000; PPIN, 2009)	no
Ceroplastes rubens Maskell, 1893 (Hemiptera: Coccidae)	red wax scale	ScaleNet, 2007; CPC, 2007	leaves, but also twigs and fruit (CPC, 2007)	uncertain	yes (Ben-Dov, 1993; ScaleNet, 2007)	no (not recorded in: PPIN, 2009; Hodgson and Henderson, 2000 states a record of it in NZ is doubtful)	no*
Ceroplastes sinensis Del Guercio, 1900 (Hemiptera: Coccidae)	Chinese wax scale	CPC, 2007; Spiller and Wise, 1982	leaves (Hill, 1987); upper leaf surfaces (Gill, 1988)	no	yes (CAB International, 1980a)	yes (PPIN, 2008Hodgson and Henderson, 2000)	no
Chionaspis salicis L. (Hemiptera: Diaspididae)	black willow scale	ScaleNet, 2007	sap sucker (Masutti, 1984)	no	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	no
Chrysomphalus dictyospermi (Morgan, 1889) (Hemiptera: Diaspididae)	Spanish red scale	ScaleNet, 2007	leaves, but sometimes on fruit and branches (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002 PPIN, 2008)	yes
Cicadella viridis Linnaeus (Hemiptera: Cicadellidae)	green leafhopper	AQSIQ, 2007; El-Sherif et al, 1999	stems, shoots (van Frankenhuyzen, 1968); branches (Jin et al, 2007); fruit (Yang, 1994)	yes ("fruit" (Yang, 1994))	yes (AQSIQ, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no*
Coccura suwakoensis (Kuwayama and Toyoda) (Hemiptera: Pseudococcidae)	quince cottony mealybug	ScaleNet, 2007	branches, stems (ScaleNet, 2007)	no	yes (ScaleNet, 2007; Ben-Dov, 1994)	no (not recorded in: Scott and Emberson, 1999; Spiller and Wise, 1982; PPIN, 2009)	no

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Coccus hesperidum hesperidum Linnaeus (Hemiptera: Coccidae)	soft brown scale	ScaleNet, 2007; Biosecurity Australia, 2005	small stems, twigs and leaves (CPC, 2007)	no	yes (ScaleNet, 2007)	yes (Spiller and Wise, 1982; Scott and Emberson, 1999)	no
Cryptococcus aceris Borchsenius, 1937 (Hemiptera: Eriococcidae)	-	ScaleNet, 2007	stems (Borkhsenius, 1939)	no	yes (ScaleNet, 2007; Tang and Hao, 1995)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no
Cryptotympana atrata Fabricius (Hemiptera: Cicadidae)	black cicada	Hill, 1987; She et al, 2005	twigs (Hill, 1987)	no	yes (AQSIQ, 2007; Hill, 1987)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009; Larivière and Fletcher, 2005)	no
Dialeurodes citri (Ashmead, 1885) (Hemiptera: Aleyrodidae)	citrus whitefly	Tao(1979)	Fruits/pods, inflorescence, leaves and stems (CPC, 2007)	no	yes (Luo and Zhou, 2001)	no (not recorded in: Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; PPIN, 2009)	no*
Diaspidiotus ostreaeformis (Curtis, 1843) (Hemiptera: Diaspididae)	oyster-shell scale	Spiller and Wise, 1982; Hill, 1987	twigs, fruit (Hill, 1987); occurs on bark (ScaleNet, 2008)	yes (CPC, 2007; Hill, 1987)	yes (ScaleNet, 2007)	yes (Charles and Henderson, 2002)	no
Diaspidiotus perniciosus (Comstock, 1881) (Hemiptera: Diaspididae)	San Jose scale	Spiller and Wise, 1982; Timlin, 1964	fruit, shoots (White et al, 1990; Hill, 1987)	yes (White et al, 1990; Hill, 1987)	yes (Deng and Nan, 2001)	yes (; Charles and Henderson, 2002)	no
Didesmococcus koreanus Borchsenius, 1955 (Hemiptera: Coccidae)	peach scale	AQSIQ, 2007	branches (Zhao, 2002)	no	yes (AQSIQ, 2007)	no (not recorded in: Hodgson and Henderson, 2000; PPIN, 2009)	no
Dolycoris baccarum (Linnaeus, 1758) (Hemiptera: Pentatomidae)	sloe bug	AQSIQ, 2007; Yu et al, 2002	leaves, young shoots, fruit (Yu et al, 2002); fruit (Soerum, 1977); apple fruit (Soerum, 1977)	yes (Yu et al, 2002)	yes (AQSIQ, 2007; CPC, 2007; Yu et al, 2002)	no (not recorded in: Larivière and Larochelle, 2004; PPIN, 2008)	yes
Drosicha contrahens Walker, 1858 (Hemiptera: Margarodidae)	mulberry coccid	ScaleNet, 2007	twigs, buds (Chu, 1934)	no	yes (ScaleNet, 2007; Xu and Lin, 2005)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2008nd)	no

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Drosicha corpulenta (Kuwana) (Hemiptera: Margarodidae)	-	ScaleNet, 2007; Xu et al, 1999a	flower buds, bark, soil (Xu et al, 1999a)	no	yes (Jia et al, 2001)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2008)	no
Dysmicoccus wistariae (Green, 1923) (Hemiptera: Pseudococcidae)	taxus mealybug	ScaleNet, 2007	trunk, branches (Hamilton, 1942)	no	yes (ScaleNet, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2008)	no
Empoasca vitis (Gothe, 1875) (Hemiptera: Cicadellidae)	small green leafhopper	Biosecurity Australia, 2005	fruit (Choi et al, 2000); leaves (CPC, 2007)	yes (citrus (Choi et al, 2000))	yes (Fu and Han, 2007; Lu et al, 2008a)	no (not recorded in:; Lariviere and Fletcher, 2005;PPIN, 2009)	no*
Eriococcus betulaefoliae Tang and Hao, 1995 (Hemiptera: Eriococcidae)	-	ScaleNet, 2007	The related *Eriococcus lagerstroemiae* is recorded on bark and branches (Zhao et al, 1998)	no	yes (ScaleNet, 2007; Tang and Hao, 1995)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2008)	no
Eriococcus tokaedae Kuwana, 1932 (Hemiptera: Eriococcidae)	acer scale	ScaleNet, 2007	The related *Eriococcus lagerstroemiae* is recorded on bark and branches (Zhao et al, 1998)	no	yes (ScaleNet, 2007; Wang, 1981)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2008)	no
Eriosoma lanigerum (Hausmann, 1802) (Hemiptera: Aphididae)	woolly apple aphid	Blackman and Eastop, 2000; Hill, 1987	trunk, twigs, roots (PPIN, 2008); twigs, branches (Hill, 1987); intercepted on *Pyrus* fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (CPC, 2007; CAB International, 1975)	yes (Teulon et al, 2004; Scott and Emberson, 1999)	no
Erthesina fullo Thunberg (Hemiptera: Pentatomidae)	yellow marmorated bug	AQSIQ, 2007	fruit (Lu et al, 1992); twigs (Hameed, 1978)	unknown (jujube (Lu et al, 1992))	yes (AQSIQ, 2007; Song and Wang, 1993)	no (not recorded in: Larivière and Larochelle, 2004)	no*
Erythroneura apicalis Nawa (Hemiptera: Cicadellidae)	grape leafhopper	Dmitriev and Dietrich, 2003-2008; Zheng et al, 2005	The related *Erythroneura vulnerata* lays eggs and feeds on leaves (Girolami et al, 2006)	no	yes (Luan et al, 2006)	no (not recorded in: Dmitriev and Dietrich (2006); PPIN, 2009)	no

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Eulecanium alnicola Chen, 1962 (Hemiptera: Coccidae)	-	ScaleNet, 2007	the related *Eulecanium ?tiliae* is found on leaves and twigs (Sharma and Dogra, 1982)	no	yes (ScaleNet, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; Hodgson and Henderson, 2000; PPIN, 2009)	no
Eulecanium excrescens (Ferris) (Hemiptera: Coccidae)	excrescent scale	CSL, 2005 Malumphy, 2005,	bark, foliage (Malumphy, 2005); twigs (Gill, 1988)	no	yes (CSL, 2005; Deng, 1985; Malumphy, 2005)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; Hodgson and Henderson, 2000; PPIN, 2009)	no
Eulecanium kunoense (Kuwana, 1907) (Hemiptera: Coccidae)	kuno scale	AQSIQ, 2007; ScaleNet, 2007	twigs (Husseiny and Madsen, 1962); leaves, twigs (Gill, 1988)	no	yes (AQSIQ, 2007; ScaleNet, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; Hodgson and Henderson, 2000; PPIN, 2009)	no
Graptopsaltria nigrofuscata (Motschulsky) (Hemiptera: Cicadidae)	large brown cicada	Yamada and Tutumi, 1989	The related *Graptopsaltria colorata* is found on the trunks and roots of *Pyrus* (Yago and Furukawa, 1936)	no	yes (Wei and Gao, 2002)	no (not recorded in: PPIN, 2009; Lariviere and Fletcher, 2009)	no
Halyomorpha halys (Stal, 1855) (Hemiptera: Pentatomidae)	brown marmorated stink bug	Takabe, 2005; Kawada and Kitamura, 1983	fruit (Takabe, 2005)	yes (Takabe, 2005)	yes (Song and Wang, 1993; Rider and Zheng, 2005)	no (not recorded in: Larivière and Larochelle, 2004; PPIN, 2008)	yes
Heliococcus bohemicus Šulc, 1912 (Hemiptera: Coccidae)	Bohemian mealybug	ScaleNet, 2007	*Heliococcus acirculus* and *H. caucasicus* are found on roots, *H. adenostomae* and *H. atriplicis* on leaves and stems (ScaleNet, 2008)	no	yes (ScaleNet, 2007)	no (not recorded in: PPIN, 2009; Hodgson and Henderson, 2000)	no

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Heliococcus destructor Borchsenius, 1941 (Hemiptera: Coccidae)	-	ScaleNet, 2007	*Heliococcus acirculus* and *H. caucasicus* are found on roots, *H. adenostomae* and *H. atriplicis* on leaves and stems (ScaleNet, 2008)	no	yes (ScaleNet, 2007)	no (not recorded in: Hodgson and Henderson, 2000; PPIN, 2009)	no
Hemiberlesia lataniae (Signoret, 1869) (Hemiptera: Diaspididae)	latania scale	ScaleNet, 2007; CPC, 2007	on any part, but mostly bark (ScaleNet, 2008); branches, leaves, fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (ScaleNet, 2007)	yes (Charles and Henderson, 2002)	no
Hemiberlesia rapax (Comstock, 1881) (Hemiptera: Diaspididae)	greedy scale	ScaleNet, 2007; Spiller and Wise, 1982	fruit, twig, shoots (PPIN, 2008)	yes (PPIN, 2008)	yes (ScaleNet, 2007)	yes (Charles and Henderson, 2002)	no
Howardia biclavis Comstock (Hemiptera: Diaspididae)	burrowing scale	ScaleNet, 2007	bark (ScaleNet, 2008)	no	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	no
Hyalopterus pruni (Geoffroy) (Hemiptera: Aphididae)	mealy plum aphid	CPC, 2007	leaves (Blackman and Eastop, 2000); buds, leaves (CPC, 2007)	no	yes (Pan, 1992; CPC, 2007)	no (not recorded in: Teulon et al, 2004)	no
Icerya aegyptiaca (Douglas, 1890) (Hemiptera: Margarodidae)	Egyptian cottony cushion scale	ScaleNet, 2007	leaves, stems, fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; ScaleNet, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	yes
Icerya purchasi purchasi Maskell, 1879 (Hemiptera: Margarodidae)	cottony cushion scale	ScaleNet, 2007; Spiller and Wise, 1982	leaves, stems, fruit (CPC, 2007)	yes (all hosts (CPC, 2007)	yes (ScaleNet, 2007)	yes (Spiller and Wise, 1982; Scott and Emberson, 1999; Scalenet (2009))	no
Icerya seychellarum (Westwood) Maskell, 1897 (Hemiptera: Margarodidae)	common white mealybug	ScaleNet, 2007	leaves and twigs (CPC, 2007)	no	yes (ScaleNet, 20077)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no
Kilifia acuminata (Signoret) (Hemiptera: Coccidae)	acuminate scale	ScaleNet, 2007	leaves (Salama and Saleh, 1971)	no	yes (ScaleNet, 2007)	no (not recorded in: Hodgson and Henderson, 2000; PPIN, 2008)	no
Ledra hyalina Kuoh and Cai, 1994 (Hemiptera: Cicadellidae)	leafhopper	Kuoh and Cai, 1994	oviposit in the bark of twigs and branches (e.g. Viggiani, 1970)	no	yes (Kuoh and Cai, 1994)	no (not recorded in: PPIN, 2008; Lariviere and Fletcher, 2009)	no

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Lepidosaphes beckii (Newman, 1869) (Hemiptera: Diaspididae)	citrus mussel scale	ScaleNet, 2007	females lay eggs on older leaves and on fruit (CPC, 2007)	yes (citrus (CPC, 2007))	yes (ScaleNet, 2007)	yes (Charles and Henderson, 2002; PPIN, 2008)	no
Lepidosaphes conchiformis (Gmelin, 1790) (Hemiptera: Diaspididae)	fig scale	ScaleNet, 2007; Kawaguchi, 1935	trunk, branches, leaves (Balali and Seyedoleslami, 1986); twigs, fruit (Kawaguchi, 1935)	yes (persimmon (Kawaguchi, 1935))	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	yes
Lepidosaphes kuwacola Kuwana, 1925 (Hemiptera: Diaspididae)	scale insect	ScaleNet, 2007	other *Lepidosaphes* spp. are associated with fruit, twigs, leaves (Watson, 2008b)	uncertain	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2008)	no*
Lepidosaphes malicola Borchsenius, 1947 (Hemiptera: Diaspididae)	Armenian comma scale	ScaleNet, 2007; Babayan and Oganesyan, 1979	all plant parts (Babayan and Oganesyan, 1979); trunk, branches, fruit (Mostaan et al, 1972)	yes (Babayan and Oganesyan, 1979)	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2008)	yes
Lepidosaphes pyrorum Tang, 1977 (Hemiptera: Diaspididae)	Zhejiang pear oyster scale	ScaleNet, 2007	other *Lepidosaphes* spp. are associated with fruit, twigs, leaves (Watson, 2008b)	yes (likely)	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2008)	yes
Lepidosaphes ulmi (Linneaus, 1758) (Hemiptera: Diaspididae)	oystershell scale	CPC, 2007; Spiller and Wise, 1982	twigs, fruit (Hill, 1987); trunk, limbs, leaves and fruit (CPC, 2007)	yes (CPC, 2007; Hill, 1987)	yes (ScaleNet, 2007)	yes (Charles and Henderson, 2002)	no
Lepidosaphes ussuriensis Borkhsenius (Hemiptera: Diaspididae)	ussuri oystershell scale	ScaleNet, 2007	leaves, branches (OEPP/EPPO, 2005)	no	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	no
Lindingaspis rossi (Maskell, 1891) (Hemiptera: Diaspididae)	araucaria black scale	PPIN, 2008	budwood, stems (PPIN, 2008); leaves (ScaleNet, 2007)	no	yes (ScaleNet, 2007)	yes (Charles and Henderson, 2002; Scott and Emberson, 1999)	no
Lopholeucaspis japonica (Cockerell, 1897) Balachowsky (1953) (Hemiptera: Diaspididae)	Japanese maple scale	ScaleNet, 2007; CPC, 2007	bark, leaves, shoots (CPC, 2007); leaves, bark of branches, sometimes on fruit (CABI/EPPO n.d.)	yes (all hosts (http://www.eppo.org/QUARANTINE/insects/Lopholeucaspis_japonica/LOPLJA_ds.pdf))	yes (CPC, 2007; ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	yes

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Lygocoris lucorum (Meyer-Dur, 1843) (Hemiptera: Miridae)	small green plant bug	Biosecurity Australia, 2005	leaves, inflorescence stalk, fruit (Liu et al, 2004)	unknown (grapes (Liu et al, 2004))	yes (Guo et al, 2005; Lu et al, 2008b)	no (not recorded in: Larivière and Larochelle, 2004; PPIN, 2008)	no*
Lygus pratensis (Linnaeus, 1758) (Hemiptera: Miridae)	tarnished plant bug	CPC, 2007	seeds (Camprag, 2006); sucks sap on "young plants" (Sekulic et al, 2005)	no	yes (CPC, 2007; Li et al, 2007c)	no (not recorded in: Larivière and Larochelle, 2004; PPIN, 2008)	no
Maconellicoccus hirsutus (Green, 1908) (Hemiptera: Pseudococcidae)	pink hibiscus mealybug	ScaleNet, 2007	inflorescence, stems, leaves, fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; ScaleNet, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2008)	yes
Macrosiphum euphorbiae (Thomas, 1878) (Hemiptera: Aphididae)	potato aphid	PPIN, 2008; Spiller and Wise, 1982	leaves (PPIN, 2008); buds (CPC, 2007); can be dispersed on foliage, stems or fruit (especially with leaves attached) (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; Xia et al, 1986)	yes (Teulon et al, 2004)	no*
Macrosiphum rosae (Linnaeus, 1758) (Hemiptera: Aphididae)	rose aphid	Blackman and Eastop, 2000; White et al, 1990	shoots, leaves (PPIN, 2008; White et al, 1990)	no	yes (CPC, 2007; Homeyer, 1976)	yes (Teulon et al, 2004;)	no
Myzus persicae (Sulzer, 1776) (Hemiptera: Aphididae)	peach potato aphid	PPIN, 2008; Blackman and Eastop, 2000	fruit (PPIN, 2008); leaves (Blackman and Eastop, 2000); leaves, flowers, shoots (CPC, 2007)	yes (PPIN, 2008)	yes (Song et al, 2006; CPC, 2007)	yes (Teulon et al, 2004)	no*
Nezara viridula (Linnaeus, 1758) (Hemiptera: Pentatomidae)	green vegetable bug	Biosecurity Australia, 2005; Spiller and Wise, 1982	fruit, growing points, inflorescence, leaves, seeds and stems (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CAB International, 1998; CPC, 2007)	yes (Larivière and Larochelle, 2004)	no
Nipaecoccus viridis (Newstead) (Hemiptera: Pseudococcidae)	spherical mealybug	ScaleNet, 2007	twigs, fruit (CPC, 2007)	yes (citrus (CPC, 2007))	yes (CPC, 2007; ScaleNet, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	yes

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Nippolachnus piri Matsumura (Hemiptera: Aphididae)	green pear aphid	Blackman and Eastop, 2000; Blackman and Eastop, 1994	leaves (Blackman and Eastop, 2000); leaves (Otake, 1995)	no	yes (Wei and Gao, 2002)	no (not recorded in: Teulon et al, 2004)	no
Orthezia urticae (Linnaeus, 1758) (Hemiptera: Ortheziidae)	nettle ensign scale	ScaleNet, 2007	stems (ScaleNet, 2008)	no	yes (ScaleNet, 2009)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2008)	no
Ovatus malisuctus (Matsumura) (Hemiptera: Aphididae)	apple leaf-curling aphid	CPC, 2007	young leaves (Blackman and Eastop, 2000)	no	yes (CPC, 2007; Shi et al, 1993)	no (not recorded in: PPIN, 2008; Teulon et al, 2004)	no
Parabemisia myricae (Kuwana) (Hemiptera: Aleyrodidae)	Japanese bayberry whitefly	CPC, 2007	leaves of citrus (Soto et al, 2002; Florida DOACS, 2006)	no	yes (CPC, 2007; Luo and Zhou, 1997)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no
Parlatoreopsis chinensis (Marlatt, 1908) (Hemiptera: Diaspididae)	Chinese obscure scale	ScaleNet, 2007; Denning, 1942	intercepted on nursery stock (Sasscer, 1918); Branches; images published online show the adult insect on bark (e.g. http://www.insectimages.org/browse/subimages.cfm?SUB=8346)	no	yes (ScaleNet, 2007; Konstantinova, 1976)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	no
Parlatoreopsis pyri (Marlatt, 1908) (Hemiptera: Diaspididae)	pear scale	ScaleNet, 2007; Kuwana and Muramatsu, 1932	intercepted on imported pear plants (Kuwana and Muramatsu, 1932)	no	yes (ScaleNet, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	no
Parlatoria camelliae Comstock, 1883 (Hemiptera: Diaspididae)	camellia parlatoria scale	ScaleNet, 2007	found almost exclusively on the leaves of the host (Gill, 1997)	no	yes (ScaleNet, 2007; Hua, 2000)	no (not recorded in: Charles and Henderson, 2002; Henderson, 2000; PPIN, 2009)	no
Parlatoria desolator McKenzie, 1960 (Hemiptera: Diaspididae)	-	ScaleNet, 2007; PPIN, 2008	other *Parlatoria* spp. attack twigs, leaves and fruit	yes (likely)	yes (ScaleNet, 2009)	yes (Charles and Henderson, 2002; PPIN, 2008; Henderson, 2000)	no

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Parlatoria oleae (Colvée, 1880) (Hemiptera: Diaspididae)	olive parlatoria scale	Chen, 2003; Stanev, 1964	leaves, branches, fruit (Chen, 2003); twigs, fruit (Hill, 1987)	yes (Hill, 1987; Chen, 2003)	yes (AQSIQ, 2007; CPC, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	yes
Parlatoria pergandii Comstock, 1881 (Hemiptera: Diaspididae)	black parlatoria scale	Spiller and Wise, 1982; Biosecurity Australia, 2005	stems, leaves, fruit (CPC, 2007); fruit (Rodrigo et al, 2004)	yes (all hosts (CPC, 2007), citrus (Rodrigo et al, 2004))	yes (ScaleNet, 2007; CPC, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	no*
Parlatoria proteus (Curtis, 1843) (Hemiptera: Diaspididae)	cattleya scale	ScaleNet, 2007	bark, twigs, fruit (Watson, 2008a); bark, twigs, leaves, fruit (Gill, 1997)	yes (all hosts (Watson, 2008a), all hosts (Gill, 1997))	yes (ScaleNet, 2007; Yang, 1997)	no (not recorded in: Charles and Henderson, 2002;; PPIN, 2009)	no*
Parlatoria theae Cockerell, 1896 (Hemiptera: Diaspididae)	tea parlatoria scale	ScaleNet, 2007	bark, twigs (Watson, 2008c)	no	yes (ScaleNet, 2007; Wang et al, 2007)	no (Charles and Henderson, 2002; PPIN, 2009)	no
Parthenolecanium corni corni (Bouché, 1844) (Hemiptera: Coccidae)	European fruit lecanium	ScaleNet, 2007; AQSIQ, 2007	leaves, twigs (Gill, 1988); leaves, branches (Supranovich and Matveichyk, 2004)	no	yes (ScaleNet, 2007; AQSIQ, 2007)	yes (PPIN, 2008; Hodgson and Henderson, 2000)	no
Parthenolecanium glandi (Kuwana, 1907) (Hemiptera: Coccidae)	-	ScaleNet, 2007	other *Pathenolecanium* spp. feed on leaves and stems	no	yes (ScaleNet, 2007)	no (not recorded in:; PPIN, 2009; Hodgson and Henderson, 2000)	no
Parthenolecanium persicae (Fabricius, 1776) (Hemiptera: Coccidae)	European peach scale	CPC, 2007; Spiller and Wise, 1982	trunk, branches, twigs and leaves (CPC, 2007); leaves, shoots (Saakyan-Baranova and Perepelitsa, 1968)	no	yes (ScaleNet, 2007; CPC, 2007)	yes (Hodgson and Henderson, 2000; Charles, 1998; PPIN, 2009)	no
Phenacoccus aceris (Signoret, 1875) (Hemiptera: Pseudococcidae)	apple mealybug	ScaleNet, 2007	bark, trunk, branches, leaves (ScaleNet, 2008)	no	yes (ScaleNet, 2007; Ben-Dov, 1994)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no
Phenacoccus pergandei Cockerell (Hemiptera: Pseudococcidae)	cottony apple scale	Yago, 1933	buds, twigs (Ueno, 1971)	no	yes (ScaleNet, 2008)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no

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Pinnaspis strachani (Cooley, 1899) (Hemiptera: Diaspididae)	Hibiscus snow scale	ScaleNet, 2007	stems, leaves, occasionally on fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (ScaleNet, 2008; CPC, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2009)	yes
Planococcus citri (Risso) (Hemiptera: Pseudococcidae)	citrus mealybug	ScaleNet, 2007	fruit, growing points, inflorescence, leaves, roots, stems (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; ScaleNet, 2007)	no (not recorded in: Spiller and Wise, 1982; PPIN, 2008)	yes
Planococcus kraunhiae (Kuwana, 1902) (Hemiptera: Pseudococcidae)	Japanese mealybug	ScaleNet, 2007	bark, shoots (Morishita, 2005a); fruit (Morishita, 2005b)	yes (persimmon (Morishita, 2005b))	yes (ScaleNet, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	yes
Platypleura kaempferi (Fabricius, 1794) (Hemiptera: Cicadidae)	Kaempfer cicada	Biosecurity Australia, 2005	adults feed on trunk of loquat tree (Uematsu and Onogi, 1980a); nymphs in soil under loquat trees (Uematsu and Onogi, 1980b)	no	yes (Feng et al, 1999)	no (not recorded in: PPIN, 2009; Lariviere and Fletcher, 2005)	no
Pseudaonidia duplex (Cockerell) (Hemiptera: Diaspididae)	camphor scale	Biosecurity Australia, 2005	leaves, branches (Shiao, 1977)	no	yes (ScaleNet, 2007; CPC, 2007)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2008)	no
Pseudaonidia trilobitiformis (Green, 1896) (Hemiptera: Diaspididae)	gingging scale	ScaleNet, 2007	leaves of mango (USDA, 1979); leaves, fruit stalks of cacao (Leigeois, 1944)	no	yes (CAB International, 1981)	no (not recorded in: Charles and Henderson, 2002; PPIN, 2008)	no
Pseudaulacaspis pentagona (Targioni Tozzetti, 1886) (Hemiptera: Diaspididae)	peach white scale	CPC, 2007; ScaleNet, 2007	Leaves, roots, stems (CPC, 2007)	no	yes (Yang et al, 2005b; ScaleNet, 2007)	no (not recorded in: PPIN, 2008;Charles and Henderson, 2002 states not present in New Zealand.)	no
Pseudococcus calceolariae (Maskell, 1879) (Hemiptera: Pseudococcidae)	scarlet mealybug	Spiller and Wise, 1982; White et al, 1990	fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CPC, 2007)	yes (Spiller and Wise, 1982; Scott and Emberson, 1999)	no
Pseudococcus comstocki (Kuwana, 1902) (Hemiptera: Pseudococcidae)	comstock mealybug	CPC, 2007; AQSIQ, 2007	fruit (PPIN, 2008); fruit, leaves (White et al, 1990)	yes (CPC, 2007; Zheng, 2006)	yes (CPC, 2007; AQSIQ, 2007)	no (not recorded in: Cox, 1977; Cox, 1987; PPIN, 2009)	yes

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Pseudococcus longispinus (Targioni Tozzetti, 1867) (Hemiptera: Pseudococcidae)	long-tailed mealybug	CPC, 2007; White et al, 1990	fruit (PPIN, 2008); fruit, leaves (White et al, 1990)	yes (CPC, 2007)	yes (CPC, 2007; ScaleNet, 2007)	yes (Scott and Emberson, 1999; Spiller and Wise, 1982; Scalenet, 2009)	no*
Pseudococcus maritimus (Ehrhorn, 1900) (Hemiptera: Pseudococcidae)	ocean mealybug	CPC, 2007; ScaleNet, 2007	intercepted on pear fruit (MAFBNZ, 2009); leaves, trunk (ScaleNet, 2008)	yes (MAFBNZ, 2009)	yes (Abudujapa and Sun, 2007)	no (not recorded in: Scott and Emberson, 1999; PPIN, 2008)	yes
Pseudococcus viburni (Signoret, 1875) (Hemiptera: Pseudococcidae)	obscure mealybug	CPC, 2007; Wakgari and Giliomee, 2004	leaves, fruit (White et al, 1990); fruit (PPIN, 2008)	yes (PPIN, 2008; White et al, 1990)	yes (ScaleNet, 2007)	yes (Cox, 1987)	no
Psylla aili Li and Yang, 1984 (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Li and Yang, 1984)	no (Charles 1998; PPIN, 2009; CPC, 2007)	yes
Psylla betulaefoliae Yang and Li, 1981 (Hemiptera: Psyllidae)	psyllid	Yang and Li, 1981	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Yang and Li, 1981)	no (not recorded in: PPIN, 2009; Charles 1998)	Yes
Psylla cengshanli Li and Yang, 1984 (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009)	unknown	yes (Li and Yang, 1984)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla changli Yang and Li, 1981 (Hemiptera: Psyllidae)	psyllid	Yang and Li, 1981	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Yang and Li, 1981)	no (not recorded in: PPIN, 2009; Charles 1998)	yes

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Psylla dianli Li and Yang, 1984 (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Li and Yang, 1984)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla erhaili Li and Yang, 1984 (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Li and Yang, 1984)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla heterobetulaefoliae Yang and Li, 1981 (Hemiptera: Psyllidae)	psyllid	Yang and Li, 1981	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Yang and Li, 1981)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla jiangli Yang and Li, 1981 (Hemiptera: Psyllidae)	psyllid	Yang and Li, 1981	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009)	unknown	yes (Yang and Li, 1981)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla kunmingli Li and Yang, 1984 (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Li and Yang, 1984)	no (not recorded in: PPIN, 2009; Charles 1998)	yes

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Psylla liaoli Yang and Li, 1981 (Hemiptera: Psyllidae)	pear psyllid	Yang and Li, 1981; Zheng and Pang, 1990	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Zheng and Pang, 1990 (Shanxi), Yang and Li, 1981)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla phaeocarpae Yang and Li, 1981 (Hemiptera: Psyllidae)	psyllid	Yang and Li, 1981	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Yang and Li, 1981)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla qianli Li and Yang (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Li and Yang, 1984)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla simaoli Li and Yang, 1984 (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Li and Yang, 1984)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla xanthisma Li and Yang, 1984 (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Li and Yang, 1984)	no (not recorded in: PPIN, 2009; Charles 1998)	yes

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Psylla xiaguanli Li and Yang, 1984 (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Li and Yang, 1984)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Psylla yunli Li and Yang, 1984 (Hemiptera: Psyllidae)	psyllid	Li and Yang, 1984	Psyllids are most often found on leaves, buds and young stems. Interceptions of psyllids on pear fruit at the New Zealand border (MAFBNZ, 2009).	unknown	yes (Li and Yang, 1984)	no (not recorded in: PPIN, 2009; Charles 1998)	yes
Pulvinaria peregrina (Borchsenius, 1953) (Hemiptera: Coccidae)	-	ScaleNet, 2007	The related *Pulvinaria tomentosa* is found on leaves and branches (ScaleNet, 2008)	no	yes (ScaleNet, 2007)	no (not recorded in: PPIN, 2008; Hodgson and Henderson, 2000)	no
Pulvinaria vitis (Linnaeus, 1758) (Hemiptera: Coccidae)	cottony grape scale	ScaleNet, 2007	leaves, twigs (Phillips, 1963)	no	yes (ScaleNet, 2008)	yes (Hodgson and Henderson, 2000; PPIN, 2008)	no
Pyrolachnus pyri (Buckton) (Hemiptera: Aphididae)	pear aphid	Blackman and Eastop, 2000; Long and Chen, 1988	branches (Blackman and Eastop, 2000)	no	yes (Long and Chen, 1988; Blackman and Eastop, 2000)	no (not recorded in: PPIN, 2008; Teulon et al, 2004)	no
Rhodococcus turanicus (Archangelskaya) (Hemiptera: Coccidae)	Turanian scale	ScaleNet, 2007; AQSIQ, 2007	most Coccidae are associated with leaves and shoots.	no	yes (AQSIQ, 2007)	no (not recorded in: Hodgson and Henderson, 2000; PPIN 2009)	no
Rhopalosiphum nymphaeae (Linnaeus, 1761) (Hemiptera: Aphididae)	plum aphid	Blackman and Eastop, 1994	leaves (Saraswati et al, 1991); young leaves, shoots (Chen et al, 2006b)	no	yes (CPC, 2007; Chen et al, 2006b)	yes (Teulon, 2004)	no
Rhopalosiphum padi (Linnaeus, 1758) (Hemiptera: Aphididae)	bird cherry-oat aphid	MAFBNZ, 2009	intercepted on pear fruit (MAFBNZ, 2009); leaves, stems, inflorescence (CPC, 2007)	yes (MAFBNZ, 2009)	yes (CPC, 2007; Hu et al, 2007)	yes (Teulon, 2004)	no

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Rhopalosiphum rufiabdominalis (Sasaki, 1899) (Hemiptera: Aphididae)	rice root aphid	Blackman and Eastop, 1994	leaves, stems, roots (CPC, 2007)	no	yes (CPC, 2007; CAB International, 1971)	yes (PPIN, 2008; Teulon et al, 2004)	no
Russellaspis pustulans pustulans (Cockerell) (Hemiptera: Asterolecaniidae)	fig scale	ScaleNet, 2007	branches (El-Imery, 1999); twigs (ScaleNet, 2008); leaves (Medina-Gaud et al, 1987) (*Russellaspis pustulans*)	no	yes (ScaleNet, 2007; CPC, 2007)	no (not recorded in: PPIN, 2008; ScaleNet, 2009, distribution does not include New Zealand)	no
Saissetia oleae oleae (Olivier, 1791) (Hemiptera: Coccidae)	olive scale	Spiller and Wise, 1982; PPIN, 2008	twig, budwood (PPIN, 2008); leaves, stems (CPC, 2007); leaves, fruit, twigs (Gill, 1988)	yes (all hosts (Gill, 1988))	yes (CPC, 2007; ScaleNet, 2007)	yes (Hodgson and Henderson, 2000)	no
Sappaphis dipirivora Zhang, 1980 (Hemiptera: Aphididae)	-	Zhang and Zhong, 1980	*Sappaphis* species generally infest leaves, branches and trunks (e.g. CPC, 2007)	no	yes (Zhang and Zhong, 1980)	no (not recorded in: PPIN, 2008; Teulon et al, 2004)	no
Sappaphis piri Matsumura (Hemiptera: Aphididae)	pear yellow mealy aphid	CPC, 2007; Blackman and Eastop, 2000	leaves (Blackman and Eastop, 2000)	no	yes (Blackman and Eastop, 2000; Ju et al, 2000)	no (not recorded in:; PPIN, 2008; Teulon et al, 2004)	no
Sappaphis sinipiricola Zhang, 1980 (Hemiptera: Aphididae)	-	Zhang and Zhong, 1980	*Sappaphis* species generally infest leaves, branches and trunks (e.g. CPC, 2007)	no	yes (Zhang and Zhong, 1980)	no (not recorded in: PPIN, 2008; Teulon et al, 2004)	no
Schizaphis piricola (Matsumura) (Hemiptera: Aphididae)	pear aphid	Blackman and Eastop, 2000; Hill, 1987	leaves (Blackman and Eastop, 2000; Hill, 1987); twigs, buds (Yago and Furuichi, 1940)	no	yes (Geoffrion, 1987; Wei and Gao, 2002)	no (not recorded in: Teulon et al, 2004; PPIN, 2009)	no
Siciunguis novena Zhang et al, 1999 (Hemiptera: Aphididae)	-	Zhang et al, 1999; Wu and Zhang, 1999	roots (Wu and Zhang, 1999); leaves of elm (Wu and Zhang, 1999)	no	yes (Zhang et al, 1999)	no (not recorded in: PPIN, 2008; Teulon et al, 2004)	no
Sphaerolecanium prunastri (Boyer de Fonscolombe, 1834) (Hemiptera: Coccidae)	blackthorn scale	ScaleNet, 2007; Biosecurity Australia, 2005	trunks, branches, twigs (CPC, 2007); branches, stems (Yang et al, 2005b)	no	yes (Yang et al, 2005b; CPC, 2007)	no (not recorded in: Hodgson and Henderson, 2000; PPIN, 2009)	no

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Stephanitis ambigua Horvath, 1912 (Hemiptera: Tingidae)	pear lace bug	Hill, 1987	leaves (Hill, 1987)	no	yes (Hill, 1987)	no (not recorded in: Larivière and Larochelle, 2004)	no
Stephanitis nashi Esaki and Takeya, 1931 (Hemiptera: Tingidae)	pear lace bug	AQSIQ, 2007; Drake and Hsiung, 1936	leaves (Drake and Hsiung, 1936); leaves, bark (Han and Yuan, 1999)	unknown	yes (Bao et al, 2001; AQSIQ, 2007)	no (not recorded in: Larivière and Larochelle, 2004; PPIN, 2008)	no*
Tessaratoma papillosa (Drury) (Hemiptera: Tessaratomidae)	litchi stink bug	CPC, 2007	shoots, leaves (CPC, 2007); fruit (Zhang, 1997)	yes (litchi (CPC, 2007))	yes (CPC, 2007; He, 2001)	no (not recorded in: Larivière and Larochelle, 2004; PPIN, 2008)	no*
Toxoptera aurantii (Boyer de Fonscolombe, 1841) (Hemiptera: Aphididae)	black citrus aphid	Blackman and Eastop, 2000; Blackman and Eastop, 1994	leaves, shoots (Blackman and Eastop, 2000; CPC, 2007)	no	yes (CPC, 2007; CAB International, 2006b)	yes (Teulon et al, 2004)	no
Toxoptera citricida (Kirkaldy, 1907) (Hemiptera: Aphididae)	tropical citrus aphid	Blackman and Eastop, 2000; Blackman and Eastop, 1994	leaves, shoots (Blackman and Eastop, 2000); newly developed leaves, shoots and flower buds (CPC, 2007)	no	yes (CPC, 2007; Zhou et al, 2005)	yes (Teulon et al, 2004)	no
Toxoptera odinae (van der Goot, 1917) (Hemiptera: Aphididae)	mango aphid	Blackman and Eastop, 2000; Blackman and Eastop, 1994	leaves, shoots (Blackman and Eastop, 2000); flowers, shoots (Autrique and Remaudiere, 1984); fruit (CPC, 2007)	uncertain (coffee (CPC, 2007))	yes (CPC, 2007; Blackman and Eastop, 2000)	no (not recorded in: Teulon et al, 2004; PPIN, 2009)	no*
Trialeurodes vaporariorum Westwood, 1856 (Hemiptera: Aleyrodidae)	greenhouse whitefly	USDA whitefly database, 2008	leaves (CPC, 2007)	no	yes (CPC, 2007)	yes (Martin and Mound, 2007; PPIN, 2009)	no
Urochela luteovaria Distant, 1881 (Hemiptera: Urostylidae)	pear stink bug	AQSIQ, 2007; Tseng and Ho, 1937	leaves, twigs, flower-buds, fruit (Tseng and Ho, 1937; Hoh, 1933)	yes (Tseng and Ho, 1937)	yes (Hoh, 1933; Tseng and Ho, 1937)	no (not recorded in: Larivière and Larochelle, 2004; PPIN, 2008)	yes
HYMENOPTERA							
Agenocimbex crataegum Huang and Zhou, 1997 (Hymenoptera: Cimbicidae)	sawfly	Huang and Zhou, 1997	The related *Agenocimbex ulmusvora* damages leaves of White elm (Yang et al, 1996)	no	yes (Huang and Zhou, 1997)	no (not recorded in: PPIN, 2008; Berry, 2007)	no

Scientific name	Common name	Associated with *Pyrus* spp. (ref)	Plant part association (all hosts)	Likely to be present on *Pyrus* fruit	Present in China	Present in New Zealand	Potential hazard*
Caliroa cerasi (Linnaeus, 1758) (Hymenoptera: Tenthredinidae)	cherry slug	Spiller and Wise, 1982; Brewer et al, 2002	leaves (PPIN, 2008; White et al, 1990; Brewer et al, 2002)	no	yes (CPC, 2007)	yes (White et al, 1990;)	no
Hoplocampa pyricola Rohwer (Hymenoptera: Tenthredinidae)	pear sawfly	AQSIQ, 2007; Harukawa, 1924	young fruit (Harukawa, 1924)	yes (Harukawa, 1924)	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2008; Berry, 2007)	yes
Janus gussakovskii Maa. (Hymenoptera: Cephidae)	stem girdler	AQSIQ, 2007	Larvae of the genus *Janus* bore in twigs and stems of forest trees and shrubs (Viitasaari, 1975)	no	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2008; Berry, 2007)	no
Janus piriodorus Yang (Hymenoptera: Cephidae)	sawfly	Zheng et al, 2001; AQSIQ, 2007	shoots (Zheng et al, 2001)	no	yes (AQSIQ, 2007; Zheng et al, 2001)	no (not recorded in: PPIN, 2008; Berry, 2007)	no
Janus pyri Okamota (Hymenoptera: Cephidae)	stem sawfly	AQSIQ, 2007; She et al, 2005	trunk, branches (She et al, 2005)	no	yes (AQSIQ, 2007; She et al, 2005)	no (not recorded in: Berry, 2007)	no
Osmia cornifrons (Radoszkowski, 1887) (Hymenoptera: Megachilidae)	horn-faced bee	Jin and Lu, 2007	pollinates pear flowers (MAAREC, 2004)	no	yes (Lu et al, 2003; Jin and Lu, 2007)	no (not recorded in: PPIN, 2008; Berry, 2007)	no
Vespa mandarinia Smith (Hymenoptera: Vespidae)	giant hornet	AQSIQ, 2007	adults of *Vespa* spp. pierce ripe fruit (Hill, 1987)	yes (Hill, 1987)	yes (AQSIQ, 2007; Wang et al, 1985)	no (not recorded in: PPIN, 2008; Berry, 2007)	yes
LEPIDOPTERA							
Acleris ferrugana (Schiffermuller and Denis, 1775) (Lepidoptera: Tortricidae)	oak leaf roller	Byun et al, 2004	The related *A. comariana* feeds on leaves and flowers (Hill, 1987); larvae of *Acleris rhombana* feed in the buds of Rosaceae (Sauphanor, 1981)	no	yes (Byun et al, 2004)	no (not recorded in: Dugdale, 1988; Scott and Emberson, 1999; PPIN, 2009; Hoare, 2001)	no
Acleris fimbriana (Thunberg, 1791) (Lepidoptera: Tortricidae)	fruit tree tortrix	AQSIQ, 2007	leaves (Meijerman and Ulenberg, 2000); apple fruit (Choi et al, 2004)	yes (based on apples)	yes (Zhang, 1994; Byun et al, 2004)	no (not recorded in: Dugdale, 1988; Hoare, 2001; Charles, 1998; PPIN, 2009)	yes
Acleris variegana Denis and Schiffermuller, 1775 (Lepidoptera: Tortricidae)	garden rose tortrix	Zhang, 1994	leaves, trunks, branches (Belosel'skaya, 1925)	no	yes (Zhang, 1994)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no

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Acrobasis pirivorella (Matsumura, 1900) (Lepidoptera: Pyralidae)	pear fruit moth	CPC, 2007; Zhang, 1994	fruit (Shutova); developing buds, flowers and fruitlets (CPC, 2007)	yes (CPC, 2007; Shutova, 1977)	yes (Wei and Gao, 2002; Zhang, 1994; Garland, 1995)	no (not recorded in: Dugdale, 1988; Hoare, 2001; Charles, 1998; PPIN, 2009)	yes
Acronicta intermedia (Warren, 1909) (Lepidoptera: Noctuidae)	raspberry budmoth	Biosecurity Australia, 2005; AQSIQ, 2007	leaves of apple (Ahn et al, 1989)	no	yes (AQSIQ, 2007; Su et al, 2004)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Acronicta rumicis (Linnaeus, 1758) (Lepidoptera: Noctuidae)	knotgrass moth	CPC, 2007; Biosecurity Australia, 2005	leaves (CPC, 2007)	no	yes (CPC, 2007; Hu and Qi, 1993)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Actias selene ningpoana Felder and Felder, 1862 (Lepidoptera: Saturniidae)	green actias moth	Biosecurity Australia, 2005	Actias selene - leaves (Green, 1983)	no	yes (Chen et al, 2006a; Zhang, 1994)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Adoxophyes orana (Fischer von Röeslerstamm, 1834) (Lepidoptera: Tortricidae)	summer fruit tortrix	Zhang, 1994; Iriciuc, 1964	fruit (Balachowsky, 1966; Fluckiger and Benz, 1982) ; leaves, fruit, trunk (CPC, 2007)	yes (Balachowsky, 1966; Fluckiger and Benz, 1982)	yes (CPC, 2007; Zhang, 1994)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Agonopterix alstroemeriana (Clerck, 1759) (Lepidoptera: Oecophoridae)	defoliating hemlock moth	MAFBNZ, 2009	previously intercepted on *Pyrus* fruit (MAFBNZ, 2009); leaves, flowers, seedheads (Hoare, 2001)	yes (MAFBNZ, 2009)	yes (Wang and Zheng, 1996; CPC, 2007)	yes (Hoare, 2001; PPIN, 2009)	no
Agrotis ipsilon (Hufnagel, 1766) (Lepidoptera: Noctuidae)	black cutworm	CPC, 2007	leaves, stalks - fruit piercing may occur (CPC, 2007)	yes (CPC, 2007)	yes (CPC, 2007; Zhao and Cheng, 2006)	yes (Dugdale, 1988; PPIN, 2009)	no*
Amsacta lactinea Cramer, 1777 (Lepidoptera: Arctiidae)	red tiger moth	AQSIQ, 2007	leaves (Mehra and Sah, 1978)	no	yes (Zhang, 1994; CPC, 2007)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Anarsia lineatella (Zeller, 1839) (Lepidoptera: Gelechiidae)	peach twig borer	CPC, 2007	shoots of *Pyrus* (CPC, 2007); fruit of *Prunus*, leaves, bark/trunk (CPC, 2007)	yes (stonefruit (CPC, 2007))	yes (Yang et al, 2005b; Zhang, 1994)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no*
Apocheima cinerarius Erschoff, 1874 (Lepidoptera: Geometridae)	mulberry geometrid	AQSIQ, 2007	leaves (Dai and Zhu, 1979; Yang et al, 2005b)	no	yes (Zhang, 1994; Yang et al, 2005b)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no

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Apocheima sp. (Lepidoptera: Geometridae)	looper	Deng and Nan, 2001	As with *A. cinerarius*, likely to be on leaves.	no	yes (Deng and Nan, 2001)	unknown (not recorded in PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Aporia crataegi (Linnaeus, 1758) (Lepidoptera: Pieridae)	hawthorn butterfly	CPC, 2007; Zhang, 1994	skeletonise leaves then feed on buds (CPC, 2007; Lyashenko, 1986)	no	yes (Bascombe, 1995; Zhang, 1994)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Archips breviplicanus Walsingham, 1900 (Lepidoptera: Tortricidae)	Asiatic leafroller	CPC, 2007; Zhang, 1994	leaves, fruit (Hitomi, 1935); fruit (Choi et al, 2004)	yes (Hitomi, 1935; apple (Choi et al, 2004))	yes (Hwang, 1974; Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Archips crataeganus (Hübner, 1799) (Lepidoptera: Tortricidae)	hawthorn leafroller	Zhang, 1994; Cehonadskih, 1970	flowers, young fruit and leaves (Anon., 1965)	yes (young 'fruit' (Anon., 1965))	yes (Zhang, 1994)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Archips fuscocupreanus (Walsingham, 1900) (Lepidoptera: Tortricidae)	apple tortrix	CPC, 2007; Byun et al, 2003	trunk, branches, older larvae also eat flowers and may graze fruit (CPC, 2007)	yes (CPC, 2007)	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Archips ingentanus (Christoph, 1881) (Lepidoptera: Tortricidae)	larger apple tortrix	Byun et al, 2003	As with other tortricids, likely to be on leaves. No evidence of association with fruit.	no	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no
Archips nigricaudanus (Walsingham, 1900) (Lepidoptera: Tortricidae)	a leaf roller	Byun et al, 2003	As with other tortricids, likely to be on leaves. No evidence of association with fruit.	no	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no
Archips rosana (Linnaeus, 1758) (Lepidoptera: Tortricidae)	European leaf roller	CPC, 2007; Zhang, 1994	fruit, flowers and leaves (Novopolskaja, 1950); leaves, but also buds, flowers and fruit (CPC, 2007)	yes (CPC, 2007; Novopolskaja, 1950)	yes (Zhang, 1994; You et al, 1983)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Archips viola (Falkovitsch, 1965) (Lepidoptera: Tortricidae)	a leaf roller	Byun et al, 2003	As with other tortricids, likely to be on leaves. No evidence of association with fruit.	no	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no

Scientific name	Common name	Associated with *Pyrus* spp. (ref)	Plant part association (all hosts)	Likely to be present on *Pyrus* fruit	Present in China	Present in New Zealand	Potential hazard*
Archips xylosteanus Linnaeus, 1758 (Lepidoptera: Tortricidae)	variegated golden tortrix	Yago, 1931; Zhang, 1994	leaves, buds, flowers, fruit (Yago, 1931); leaves and newly-set fruit (Rafal'skii, 1977)	yes (Yago, 1931; apples and 'other' fruit (Rafal'skii, 1977))	yes (Zhang, 1994; Hwang, 1974)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Blastodacna pyrigalla Yang, 1977 (Lepidoptera: Cosmopterigidae)	pear fruit borer	AQSIQ, 2007	The related *Blastodacna atra* infests leaves, buds and shoots of apple (Chekhonadskikh, 1974)	no	yes (AQSIQ, 2007)	no (not recorded in:; PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Bucculatrix pyrivorella Kuroko, 1964 (Lepidoptera: Lyonetiidae)	pear leaf miner	Fujie, 1982; Biosecurity Australia, 2005	leaves (Fujie, 1982)	no	yes (Wei and Gao, 2002)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Carposina sasakii Matsumura, 1900 (Lepidoptera: Carposinidae)	peach fruit borer	CPC, 2007; Zhang, 1994	fruit (CPC, 2007); fruit (Ishiguri and Toyoshima, 2006)	yes (CPC, 2007)	yes (Zhang, 1994; Wei and Gao, 2002)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Choreutis pariana (Clerck, 1759) (Lepidoptera: Choreutidae)	apple-and-thorn skeletonizer	Gorska-Drabik and Golan, 2004; Zhang, 1994	leaves of apple (Yin et al, 1987)	no	yes (CPC, 2007; Yin et al, 1987)	no (not recorded in:; PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Choristoneura diversana (Hubner, 1817) (Lepidoptera: Tortricidae)	a leaf roller	Byun et al, 2003	As with other tortricids, likely to be on leaves. No evidence of association with fruit.	no	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no
Choristoneura longicellanus (Walsingham, 1900) (Lepidoptera: Tortricidae)	Common apple leaf roller	Byun et al, 2003 AQSIQ, 2007 (as *Hoshinoa longicellana*)	As with other tortricids, likely to be on leaves. As *Hoshinoa*: leaves (Meijerman and Ulenberg (2008a); leaves, fruit (Nakayama, 1937a)	yes (apples (Nakayama, 1937a))	yes (Byun et al, 2003; AQSIQ, 2007 (as *Hoshinoa*); Zhang, 1994(as *Hoshinoa*)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Choristoneura luticostana (Falkovitsch, 1965) (Lepidoptera: Tortricidae)	a leaf roller	Byun et al, 2003	As with other tortricids, likely to be on leaves. No evidence of association with fruit.	no	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no

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Conobathra bifidella Leech, 1889 (Lepidoptera: Pyralidae)	lump insect	Muramatsu, 1925; Zhang, 1994	adults cut into the stalks of the fruit, larvae devour the contents of the bud (Muramatsu, 1925)	no	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Conogethes punctiferalis (Guenée, 1854) (Lepidoptera: Pyralidae)	yellow peach moth	AQSIQ, 2007; Lee et al, 2000	fruit (Lee et al, 2000); larvae bore into fruit, stems (CPC, 2007)	yes (all hosts (CPC, 2007), Lee et al, 2000)	yes (Zhang, 1994; CPC, 2007)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Cossus cossus Linnaeus (Lepidoptera: Cossidae)	carpenter moth	CPC, 2007; Zhang, 1994	bark, trunks (Maini et al, 2000; CPC, 2007)	no	yes (CPC, 2007; Zhang, 1994)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Cydia funebrana Treitschke (Lepidoptera: Tortricidae)	plum fruit moth	Venette et al, 2003	Fruit (Venette et al, 2003)	Yes (Venette et al, 2003)	Yes (CPC, 2007)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Cydia inopinata Heinrich (Lepidoptera: Tortricidae)	Manchurian fruit moth	CPC, 2007; Zhang, 1994	fruit flesh and pips/seeds (CPC, 2007); leaves, fruit (Lopatina, 1978); apple fruit (Kolmakova, 1958; Kolmakova, 1965)	yes (apple (Lopatina, 1978; CPC, 2007)	yes (Zhang, 1994; Garland, 1995)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Cydia pomonella Linnaeus, 1758 (Lepidoptera: Tortricidae)	codling moth	Spiller and Wise, 1982; Zhang, 1994	fruit (PPIN, 2008; White et al, 1990; Hill, 1987)	yes (CPC, 2007; Hill, 1987)	yes (Zhang, 1994; Garland, 1995)	yes (Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no
Eumeta minuscula Butler (Lepidoptera: Psychidae)	bagworm	Zhang, 1994	*Eumeta* spp. are defoliators.	no	yes (Zhang, 1994; CPC, 2007)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Eumeta variegata Snellen (Lepidoptera: Psychidae)	cotton bug worm	Biosecurity Australia, 2005	leaves (Su et al, 2004; Sun et al, 1999)	no	yes (Wang and Xia, 2000; Zhang, 1994)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Euproctis chrysorrhoea (Linnaeus, 1758) (Lepidoptera: Lymantriidae)	brown-tail moth	Dlabola and Syrinek, 1962; Zhang, 1994	fruit (Auersch, 1971); apple fruit (Auersch, 1971)	yes (Auersch, 1971)	yes (CPC, 2007; You et al, 1983)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Euproctis similis (Fuessly, 1775) (Lepidoptera: Lymantriidae)	mulberry tussock moth	AQSIQ, 2007; Gromova and Rogacheva, 1976	leaves (Gromova and Rogacheva, 1976); leaves (Aleksidze and Bezhanishvili, 1974)	no	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no

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Euzophera pyriella Yang (Lepidoptera: Pyralidae)	pyralid moth	AQSIQ, 2007; Lu, 2004	trunks, branches, fruit (Lu, 2004; Song et al, 1994a)	yes (Lu, 2004; Song et al, 1994a)	yes (AQSIQ, 2007; Lu, 2004)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Gastropacha quercifolia Linnaeus (Lepidoptera: Lasiocampidae)	snout moth	AQSIQ, 2007; Zhang, 1994	leaves in various trees (Goidanich, 1983); feeding on the flower- and leaf-buds (Bibolini, 1960)	no	yes (AQSIQ, 2007; Zhang, 1994)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Grapholita molesta (Busck, 1916) *Cydia molesta* (Busck) (Lepidoptera: Tortricidae)	oriental fruit moth	PPIN, 2008; Zhang, 1994	fruit (PPIN, 2008; Pan et al, 2002); shoots, fruit (Hill, 1987)	yes (Hill, 1987; Il'ichev and Williams, 2006)	yes (Zhang, 1994; Garland, 1995)	yes (PPIN, 2009;; Hoare, 2001)	no
Helicoverpa armigera (Hubner, 1805) (Lepidoptera: Noctuidae)	cotton bollworm	Biosecurity Australia, 2005	larvae feed on fruit as well as leaves (CPC, 2007)	yes (tomatoes (CPC, 2007))	yes (Zhang, 1994; CPC, 2007)	yes (Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2009)	no
Holcocerus vicarius Walker, 1865 (Lepidoptera: Cossidae)	-	She et al, 2005	The related *Holcocerus hippophaecolus* is associated with stems and roots (Zong et al, 2005)	no	yes (Yuan et al, 2007; She et al, 2005)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Homona magnanima Diakonoff, 1948 (Lepidoptera: Tortricidae)	-	CPC, 2007	leaves (CPC, 2007)	no	yes (CPC, 2007; Zhang, 1994; Li et al, 2005c)	no (not recorded in:; PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Hyphantria cunea Drury, 1770 (Lepidoptera: Arctiidae)	fall webworm	Varjas and Senhal, 1973; Zhang, 1994	branches (Varjas and Senhal, 1973); leaves (CPC, 2007); larvae eat foliage and fruit within their webs (Brunner and Zack, 1993)	yes (all hosts (Brunner and Zack, 1993))	yes (CPC, 2007; Yang and Zhang, 2007)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Illiberis pruni Dyar, 1905 (Lepidoptera: Zygaenidae)	pear leaf worm	AQSIQ, 2007; Zhang, 1994	leaves (Liu, 1941)	no	yes (Zhang, 1994; Wei and Gao, 2002)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Leucoptera malifoliella Costa, 1836 (Lepidoptera: Lyonetiidae)	pear leaf miner	Matis, 2004; Zhang, 1994	leaves, stem and calyx ends of fruit (CPC, 2007); fruit (Maciesiak, 1999; Mey, 1988)	yes (CPC, 2007; apple (Mey, 1988))	yes (CPC, 2007; Garland, 1995)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes

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Lymantria dispar Linnaeus, 1758 (Lepidoptera: Lymantriidae)	gypsy moth	Liotta, 1970; Zhang, 1994	unripe fruit (Liotta, 1970); inflorescence, leaves (CPC, 2007)	yes (Liotta, 1970)	yes (Zhang, 1994; CPC, 2007)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Lymantria monacha Linnaeus (Lepidoptera: Lymantriidae)	nun moth	CPC, 2007	bark, leaves (CPC, 2007)	no	yes (CPC, 2007; Zhang, 1994)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Lyonetia clerkella Linnaeus (Lepidoptera: Lyonetiidae)	apple leaf miner	Dimic, 1964; Yao, 1994	leaves (Dimic, 1964); bark (Yao, 1994)	no	yes (Ding et al, 2005; CPC, 2007)	no (not recorded in: Dugdale, 1988)	no
Malacosoma neustria Linnaeus, 1758 (Lepidoptera: Lasiocampidae)	common lackey moth	CPC, 2007; Zhang, 1994	leaves, stems and buds (Gorbunov, 1991); leaves, twigs (CPC, 2007); leaves (Tarasenko and Gorbunov, 1981); apple fruit (Rilishkene and Zayanchkauskas, 1980)	yes (apple fruit (Rilishkene and Zayanchkauskas, 1980))	yes (CPC, 2007; Dang and Wang, 2002)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Malacosoma neustria testacea Motschulsky (Lepidoptera: Lasiocampidae)	-	AQSIQ, 2007	leaves (Hokkaido Research Center, 2008)	no	yes (AQSIQ, 2007; Wang et al, 2004)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Malacosoma parallela Staudinger, 1887 (Lepidoptera: Lasiocampidae)	mountain ring silk moth	CPC, 2007	leaves (CPC, 2007)	no	yes (CPC, 2007; Yang et al, 2005b)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Marumba gaschkewitschii Bremer and Grey (Lepidoptera: Sphingidae)	peach horn worm	Pittaway and Kitching, 2008; AQSIQ, 2007	branches (Pittaway and Kitching, 2008)	no	yes (AQSIQ, 2007; Zhang, 1994)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Monema flavescens Walker (Lepidoptera: Limacodidae)	oriental moth	Nawa, 1938; AQSIQ, 2007	leaves (Togashi and Ishikawa, 1996; Mevzos, 1935)	no	yes (Zhang, 1994; CPC, 2007)	no (not recorded in: PPIN, 2009; Hoare, 2001)	no
Odites leucostola (Meyrick, 1921) (Lepidoptera: Oecophoridae)	lecithocerid moth	AQSIQ, 2007	other Odites species are leaf-skeletonisers (Evans, 1969)	no	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Odonestis pruni Linnaeus (Lepidoptera: Lasiocampidae)	apple caterpillar	AQSIQ, 2007	members of the family Lasiocampidae are most often leaf-feeders	no	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no

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Oraesia emarginata Fabricius (Lepidoptera: Noctuidae)	fruit piercing moth	Biosecurity Australia, 2005	fruit (Liu, 2002; Liu and Kuang, 2001)	yes (citrus (Liu, 2002))	yes (Liu and Kuang, 2001; Liu, 2002)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Oraesia excavata (Butler) (Lepidoptera: Noctuidae)	fruit piercing moth	CPC, 2007; Liu, 2002	fruit (Liu, 2002)	yes (Liu, 2002; Liu and Kuang, 2001)	yes (Liu, 2002; CPC, 2007)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Orgyia postica Walker, 1855 (Lepidoptera: Lymantriidae)	cocoa tussock moth	CPC, 2007	stalks, fruit, leaves (CPC, 2007); leaves, flowers (Kannan and Rao, 2007); mango fruit (Fasih et al, 1989)	yes (mango (CPC, 2007))	yes (CPC, 2007; Zhang, 1994)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Pandemis cerasana (Hübner) (Lepidoptera: Tortricidae)	common twist moth	Civolani and Pasqualini, 2000; Zhang, 1994	fruit (Barbara et al, 1994); shoots, inflorescences, fruit, leaves (CPC, 2007)	yes (CPC, 2007; Barbara et al, 1994)	yes (CPC, 2007; Zhang, 1994)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Pandemis chlorgrapta (Meyrick, 1921) (Lepidoptera: Tortricidae)	a leaf roller	Byun et al, 2003	As with other tortricids, likely to be on leaves. No evidence of association with fruit.	no	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no
Pandemis cinnamomeana (Treitschke, 1830) (Lepidoptera: Tortricidae)	a leaf roller	Byun et al, 2003	As with other tortricids, likely to be on leaves. No evidence of association with fruit.	no	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no
Pandemis heparana (Denis and Schiffermüller, 1775) (Lepidoptera: Tortricidae)	apple brown tortrix	CPC, 2007; Zhang, 1994	fruit (Castellari, 1988); superficial feeding on fruit, also leaves and flowers (Bradley et al, 1973); leaves, fruit (CPC, 2007)	yes (CPC, 2007; Castellari, 1988)	yes (CPC, 2007; Zhang, 1994)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Parasa consocia Walker, 1865 (Lepidoptera: Limacodidae)	green cochlid	AQSIQ, 2007	leaves (Mevzos, 1935)	no	yes (AQSIQ, 2007)	no (PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Parasa hilarata Staudinger, 1887 (Lepidoptera: Limacodidae)	nettle grub	AQSIQ, 2007	leaves (Mevzos, 1935)	no	yes (AQSIQ, 2007)	no (PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Parasa lepida Cramer, 1799 (Lepidoptera: Limacodidae)	blue-striped nettle grub	Sandhu and Sohi, 1980	leaves (Sandhu and Sohi, 1980); leaves (CPC, 2007)	no	yes (Wu and Huang, 1983; Zhang, 1994)	no (PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no

Scientific name	Common name	Associated with *Pyrus* spp. (ref)	Plant part association (all hosts)	Likely to be present on *Pyrus* fruit	Present in China	Present in New Zealand	Potential hazard*
Pempelia heringii Ragonot, 1888 (Lepidoptera: Pyralidae)	pear fruit borer	Hill, 1987; Zhang, 1994	fruit (Hill, 1987)	yes (Hill, 1987)	yes (Zhang, 1994; Sun et al, 1992)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Peridroma saucia (Hübner, 1808) (Lepidoptera: Noctuidae)	pearly underwing moth	CPC, 2007	stems, leaves, fruit (CPC, 2007); leaves (Sannino, 2005); fruit, stems, leaves (Bibolini, 1970)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; Kuang, 1985)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Phalera flavescens Bremer and Grey, 1852 (Lepidoptera: Notodontidae)	cherry catterpillar	AQSIQ, 2007; Zhang, 1994	leaves, buds (Lee, 1965)	no	yes (AQSIQ, 2007; Zhang, 1994)	no (PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Phlossa conjuncta (Walker, 1855) (Lepidoptera: Limacodidae)	slug catterpillar	AQSIQ, 2007	leaves (Zhang et al, 1983)	no	yes (AQSIQ, 2007)	no (PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Phyllonorycter ringoniella Matsumura, 1931 (Lepidoptera: Gracillariidae)	apple leaf miner	AQSIQ, 2007	leaves (Chen and Li, 2005)	no	yes (Zhang and Huang, 1990; CPC, 2007)	no (PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Proeulia chrysopteris (Butler, 1883) (Lepidoptera: Tortricidae)	grapevine leaf-rolling tortricid	CPC, 2007	leaves, flowers, green shoots, fruit (CPC, 2007)	yes (CPC, 2007)	yes (Zhang, 1994)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no*
Ptycholoma lecheana (Linnaeus, 1758) (Lepidoptera: Tortricidae)	a leaf roller	Byun et al, 2003	As with other tortricids, likely to be on leaves. No evidence of association with fruit.	no	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no
Ptycholoma plumbeolana (Bremer, 1864) (Lepidoptera: Tortricidae)	a leaf roller	Byun et al, 2003	As with other tortricids, likely to be on leaves. No evidence of association with fruit.	no	yes (Byun et al, 2003)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no
Selepa celtis Moore (Lepidoptera: Noctuidae)	noctuid moth	CPC, 2007; Zhang, 1994	leaves (Singh et al, 1997)	no	yes (Zhang, 1994; Wu and Huang, 1984)	no (Hoare, 2001; Dugdale, 1988)	no
Spilonota albicana (Motschulsky) (Lepidoptera: Tortricidae)	large apple fruit moth	AQSIQ, 2007	fruit (Ovsyannikova and Grichanov, 2008); *Spilonota* spp. are associated with buds and young shoots, as well as flowers and fruit.	unknown	yes (AQSIQ, 2007; Ovsyannikova and Grichanov, 2008)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes

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Spilonota lechriaspis (Meyrick, 1932) (Lepidoptera: Tortricidae)	tipshoot tortrix	AQSIQ, 2007; Nakayama, 1937b	leaves (Nakayama, 1937b); terminal buds, young shoots (Yuan et al, 2000)	unknown	yes (AQSIQ, 2007; Zhang, 1994)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Spilonota ocellana (Denis and Schiffermuller, 1775) (Lepidoptera: Tortricidae)	eye-spotted bud moth	CPC, 2007; Zhang, 1994	buds (Hill, 1987); flowers, leaves, sometimes the fruit surface (CPC, 2007)	yes (CPC, 2007; Hill, 1987)	yes (CAB International, 1980b; Bai, 1983)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Spodoptera litura Fabricius (Lepidoptera: Noctuidae)	taro caterpillar	PPIN, 2008	leaves (PPIN, 2008); leaves (CPC, 2007)	no	yes (CPC, 2007; Zhang, 1994)	yes (PPIN, 2009; Hoare, 2001)	no
Spulerina astaurota (Meyrick, 1922) (Lepidoptera: Gracillariidae)	pear barkminer	Harukawa and Kumashiro, 1930; Zhang, 1994	green tissues of bark (Harukawa and Kumashiro, 1930); stem-miner (Kumata et al, 1988)	no	yes (Biosecurity Australia, 2005)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	no
Synanthedon hector Butler (Lepidoptera: Sesiidae)	cherry tree borer	Biosecurity Australia, 2005	branches, trunks (Kang et al, 1991)	no	yes (CPC, 2007)	no (; PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Telphusa chloroderces Meyrick, 1929 (Lepidoptera: Gelechiidae)	black star leaf roller	AQSIQ, 2007	*Telphusa* spp. feed on leaves, buds and green shoots (e.g. Samet, 1982)	no	yes (AQSIQ, 2007)	no (PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Thosea sinensis Walker (Lepidoptera: Limacodidae)	nettle grub	AQSIQ, 2007	leaves (Braithwaite, 1941; Duong et al, 1998)	no	yes (Zhang, 1994; CPC, 2007)	no (not recorded in:; PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
Xestia c-nigrum (Linnaeus) (Lepidoptera: Noctuidae)	spotted cutworm	CPC, 2007	larvae feed on developing shoots and plant buds (CPC, 2007); buds of grapevines (Dibble et al, 1979); fruiting buds or fruitlets (TFREC, 2008)	yes (tree fruit (TFREC, 2008))	yes (CPC, 2007; Zhang, 1994)	no (not recorded in: Dugdale, 1988; Hoare, 2001; PPIN, 2009)	yes
Zeuzera pyrina Linnaeus, 1761 (Lepidoptera: Cossidae)	wood leopard moth	CPC, 2007; Zhang, 1994	trunk, branches, leaves, shoots (Castellari, 1986)	no	yes (CPC, 2007; Huaiwen et al, 2004)	no (not recorded in: PPIN, 2009; Hoare, 2001; Dugdale, 1988)	no
ORTHOPTERA							

Scientific name	Common name	Associated with *Pyrus* spp. (ref)	Plant part association (all hosts)	Likely to be present on *Pyrus* fruit	Present in China	Present in New Zealand	Potential hazard*
Tegra novaehollandiae (Haan, 1842) (Orthoptera: Tettigoniidae)	-	She et al, 2005	trunks, leaves (She et al, 2004) (*T. novaehollandiae-viridinotata*)	no	yes (She et al, 2005; She et al, 2004)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2008)	no
THYSANOPTERA							
Caliothrips fasciatus (Pergande) (Thysanoptera: Thripidae)	North American bean thrips	Lewis, 1929	fruit, foliage (Lewis, 1929)	yes	yes	no (not recorded in PPIN, 2008; Mound and Walker, 1982)	yes
Frankliniella occidentalis (Pergande, 1895) (Thysanoptera: Thripidae)	western flower thrips	Klein and Ben-Dov, 1995; MAFBNZ, 2009)	fruit (Klein and Ben-Dov, 1995); intercepted on *Pyrus* fruit (MAFBNZ, 2009)	yes (Klein and Ben-Dov, 1995; MAFBNZ, 2009)	yes (Cheng et al, 2006; Zhou et al, 2006)	yes (PPIN, 2008; Davidson et al, 2007)	no*
Heliothrips haemorrhoidalis Bouché (Thysanoptera: Thripidae)	-	Abraham and Padmanaban, 1966; Spiller and Wise, 1982	leaves, fruit (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; CAB International, 1961)	yes (Spiller and Wise, 1982; Scott and Emberson, 1999)	no
Thrips flavus Schrank, 1776 (Thysanoptera: Thripidae)	honeysuckle thrips	CPC, 2007; Verma, 1979	fruit (Garcia et al, 2003); shoots, flowers (Wen and Lee, 1982); leaves, flowers (CPC, 2007)	yes (Citrus spp. (Garcia et al, 2003))	yes (Huang et al, 2004)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999)	yes
Thrips hawaiiensis (Morgan, 1913) (Thysanoptera: Thripidae)	Hawaiian flower thrips	Manzari and Golmohammadzadeh-Khiaban, 2000	flowers (CPC, 2007); flowers, young fruit (Chiu et al, 1991)	yes (citrus (Chiu et al, 1991))	yes (CPC, 2007)	no (not recorded in: Spiller and Wise, 1982; Scott and Emberson, 1999; PPIN, 2008)	yes
Thrips tabaci Lindeman, 1889 (Thysanoptera: Thripidae)	thrips	LeGrand, 2001	fruit, flowers, leaves, stems (CPC, 2007); commonly intercepted on various fruit at the NZ border	yes (all hosts (CPC, 2007))	yes (Zhao et al, 2004; Xu et al, 2007)	yes (Scott and Emberson, 1999; Spiller and Wise, 1982)	no*
MITES							
Acarus immobilis Griffiths, 1964 (Acarina: Acaridae)	flour mite	MAFBNZ, 2009	previously intercepted on *Pyrus* fruit (MAFBNZ, 2009); stored grain (Chmielewski, 2004)	yes (MAFBNZ, 2009)	yes (Li et al, 2005a; Zou and Wang, 1989)	yes (Ramsay, 1980)	no

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Aculus fockeui (Nalepa and Trouessart, 1891) (Acarina: Eriophyidae)	peach silver mite	CPC, 2007	buds, leaves (CPC, 2007)	no	yes (CPC, 2007; Huang et al, 1994)	yes (Ramsay, 1980; Manson, 1987)	no
Aculus schlechtendali (Nalepa, 1890) (Acarina: Eriophyidae)	apple rust mite	Easterbrook, 1979; Hill, 1987	leaves (Hill, 1987); leaves, developing fruitlets (CPC, 2007)	yes (all hosts (CPC, 2007))	yes (Li and Cai, 1996)	yes (Manson, 1984; Charles, 1998)	no
Amblyseius cucumeris Oudemans (Acarina: Phytoseiidae)	amblyseiid mite	Zhang et al, 2006	predatory mite; eggs laid on leaves (CPC, 2007)	no	yes (Zhang et al, 2006; CPC, 2007)	yes (Manson, 1987; Ramsay, 1980)	no
Amphitetranychus viennensis (Zacher, 1920) (Acarina: Tetranychidae)	Hawthorn spider mite	Kishimoto and Adachi, 2006; Jeppson et al, 1975	leaves, bark (CPC, 2007; Jeppson et al, 1975); fruit (Biosecurity Australia, 2005; CFIA, 2008)	yes (Biosecurity Australia, 2005; CFIA, 2008)	yes (CPC, 2007; Garland, 1995; Li et al, 1998)	no (not recorded in: Manson, 1987; PPIN, 2009)	yes
Bryobia praetiosa Koch, 1836 (Acarina: Tetranychidae)	clover mite	Gupta et al, 1975; Ramdas-Menon and Swaraj, 1968	leaves (Ramdas-Menon and Swaraj, 1968)	no	yes (Liang et al, 2004)	yes (Manson, 1987; Ramsay, 1980)	no
Bryobia rubrioculus (Scheuten, 1857) (Acarina: Tetranychidae)	brown apple mite	CPC, 2007; Jeppson et al, 1975	leaves (Yang et al, 2005b); buds, leaves, branches, stems (Jeppson et al, 1975); fruit (Chmielewski, 1998)	yes (apple fruit (Chmielewski, 1998))	yes (CPC, 2007; AQSIQ, 2007)	yes (Manson, 1987; Ramsay, 1980)	no
Cenopalpus ruber Wainstein, 1960 (Acarina: Eriophyidae)	false spider mite	AQSIQ, 2007	The related *Cenopalpus pulcher* is found on leaves (Jeppson et al, 1975)	no	yes (AQSIQ, 2007)	no (not recorded in: PPIN, 2008; Manson, 1987; PPIN, 2009)	no
Eotetranychus carpini (Oudemans, 1905) (Acarina: Tetranychidae)	yellow mite	Ma and Yuan, 1981; Westigard et al, 1979	bark, leaves, buds (Westigard and Berry, 1970); leaves, limbs (Jeppson et al, 1975)	no	yes (Ma and Yuan, 1981)	no (not recorded in: Ramsay, 1980; Manson, 1987 PPIN, 2009)	no
Eotetranychus pruni (Oudemans, 1931) (Acarina: Tetranychidae)	hickory scorch mite	AQSIQ, 2007; Migeon and Dorkeld, 2006	bark, leaves of grapevines (Balevski, 1980)	no	yes (AQSIQ, 2007; CPC, 2007)	no (not recorded in: Ramsay, 1980; Manson, 1987; PPIN, 2009)	no

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Epitrimerus pyri (Nalepa, 1891) (Acarina: Eriophyidae)	pear rust mite	Jeppson et al, 1975; Gonzalez, 1981	leaves (Amrine and Stasny, 2005; Hill, 1987); leaves, fruit (Jeppson et al, 1975); leaves, fruit (CPC, 2007)	yes (CPC, 2007; Jeppson et al, 1975)	yes (Biosecurity Australia, 2005)	yes (Manson, 1987)	no
Eriophyes pyri (Pagenstecher, 1857) (Acarina: Eriophyidae)	pear leaf blister mite	Gonzalez, 1981; White et al, 1990	fruit, leaves, shoots (PPIN, 2008); flowers (Freriks, 1968); leaves, fruit, buds (Jeppson et al, 1975); leaves, fruit (Hill, 1987)	yes (Jeppson et al, 1975; Hill, 1987)	unknown	yes (Manson, 1987; Ramsay, 1980)	no
Eutetranychus orientalis (Klein, 1936) (Acarina: Tetranychidae)	oriental red mite	Jeppson et al, 1975; Karnkowski, 2006	leaves (Jeppson et al, 1975; CPC, 2007)	no	yes (CPC, 2007; CAB International, 2007)	no (not recorded in: Ramsay, 1980; Manson, 1987; PPIN, 2009)	no
Glycyphagus domesticus (De Geer, 1778) (Acarina: Glycyphagidae)	common house mite	MAFBNZ, 2009	fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (MAFBNZ, 2009; Li et al, 2005)	yes (Ramsay, 1980)	no
Kleemannia sp. (Acarina: Ameroseiidae)	house dust mite	MAFBNZ, 2009	intercepted on ya pear (*Pyrus bretschneideri*) from China (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (intercepted on Ya pear from China (MAFBNZ, 2009)	unknown	no
Metaseiulus occidentalis (Nesbitt, 1951) (Acarina: Phytoseiidae)	predatory mite	MAFBNZ, 2009	intercepted on pear fruit (MAFBNZ, 2009); predacious mite (CPC, 2007)	yes (MAFBNZ, 2009)	yes (CPC, 2007; Deng et al, 1990)	yes (Spain and Luxton, 1971; Ramsay, 1980)	no
Oligonychus mangiferus (Rahman and Sapra, 1940) (Acarina: Tetranychidae)	-	Jeppson et al, 1975	leaves (Jeppson et al, 1975; Zhang and Fu, 2006)	no	yes (Zhang and Fu, 2006)	no (not recorded in: Manson, 1987; Ramsay, 1980)	no
Panonychus citri (McGregor, 1916) (Acarina: Tetranychidae)	citrus red mite	Jeppson et al, 1975; Kishimoto and Adachi, 2006	leaves (Gotoh and Kubota, 1997); leaves, fruit (CPC, 2007); leaves, fruit of oranges (Jeppson et al, 1975)	yes (all hosts (CPC, 2007))	yes (Jeppson et al, 1975; Shi and Feng, 2006)	yes (Manson, 1987; Ramsay, 1980; PPIN, 2008)	no

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Panonychus ulmi (Koch, 1836) (Acarina: Tetranychidae)	European red spider mite	Sidljarevic, 1965; Jeppson et al, 1975	leaves, buds (PPIN, 2008); leaves (White et al, 1990; Asquith, 1964); intercepted on pear fruit (MAFBNZ, 2009); leaves (Jeppson et al, 1975; CPC, 2007; Hill, 1987)	yes (MAFBNZ, 2009)	yes (Wei and Gao, 2002; Deng and Nan, 2001)	yes (Manson, 1987; Ramsay, 1980; PPIN, 2008)	no
Phyllocoptes pyri Kuang and Hong, 1992 (Acarina: Eriophyidae)	-	Kuang et al, 1992	*Phyllocoptes* spp. are most often associated with leaves.	no	yes (Kuang et al, 1992)	no (not recorded in: Manson, 1987; PPIN, 2008)	no
Polyphagotarsonemus latus (Banks) (Acarina: Tarsonemidae)	broad mite	Lin and Zhang, 1999	leaves, flowers (Jeppson et al, 1975)	no	yes (Lin and Zhang, 1999)	yes (Manson, 1987; Ramsay, 1980)	no
Proctolaelaps sp. (Acarina: Ascidae)	predatory mite	MAFBNZ, 2009	intercepted on Ya pear fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (intercepted on Ya pear from China (MAFBNZ, 2009)	unknown	no
Tarsonemus confusus Ewing, 1939 (Acarina: Tarsonemidae)	-	PPIN, 2008; MAFBNZ, 2009	leaves (PPIN, 2008); fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (MAFBNZ, 2009; Wang et al, 1999)	yes (Ramsay, 1980)	no
Tarsonemus yali Lin and Zhang, 2006 (Acarina: Tarsonemidae)	tarsonemid mite	MAFBNZ, 2009; Lin and Zhang, 2006	fruit (MAFBNZ, 2009; Lin and Zhang, 2006)	yes (MAFBNZ, 2009; Lin and Zhang, 2006)	yes (MAFBNZ, 2009; Lin and Zhang, 2006)	no (not recorded in: Lin and Zhang, 2006)	yes
Tetranychus kanzawai Kishida (Acarina: Tetranychidae)	Kanzawa spider mite	CPC, 2007; Jeppson et al, 1975	leaves, stems (CPC, 2007) fruit of grapevine (Ho and Chen, 1994)	Uncertain	yes (CPC, 2007; Wei and Gao, 2002)	no (not recorded in: Ramsay, 1980; Manson, 1987)	yes
Tetranychus truncatus Ehara, 1956 (Acarina: Tetranychidae)	cassava mite	MAFBNZ, 2009; Migeon and Dorkeld, 2006	fruit (MAFBNZ, 2009); leaves (CPC, 2007)	yes (MAFBNZ, 2009)	yes (Bolland et al, 1998; CPC, 2007)	no (not recorded in: Ramsay, 1980; Manson, 1987)	yes
Tetranychus turkestani (Ugarov and Nikolski, 1937) (Acarina: Tetranychidae)	strawberry spider mite	Jeppson et al, 1975; Zhang et al, 2006	trunk, leaves (CPC, 2007); leaves (Jeppson et al, 1975)	no	yes (AQSIQ, 2007; Zhang et al, 2006)	yes (Manson, 1987; Manson, 1967)	no

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Tetranychus urticae Koch (Acarina: Tetranychidae)	two-spotted spider mite	Kishimoto and Adachi, 2006; White et al, 1990	leaves (White et al, 1990; Asquith, 1964); fruit (Izawa, 1999); intercepted on pear fruit (MAFBNZ, 2009); fruit (CPC, 2007)	yes (Izawa, 1999; MAFBNZ, 2009)	yes (CPC, 2007; Biosecurity Australia, 2005)	yes (Manson, 1987; Ramsay, 1980)	no*
Tydeus sp. (Acarina: Tydeidae)	tydeid mite	MAFBNZ, 2009	intercepted on Ya pear fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (intercepted on Ya pear from China (MAFBNZ, 2009)	unknown	no
Tyrophagus neiswanderi Johnston and Bruce (Acarina: Acaridae)	cucumber mite	PPIN, 2008; MAFBNZ, 2009	leaves (PPIN, 2008); fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (MAFBNZ, 2009; Teng et al, 1988)	yes (Manson, 1987; Ramsay, 1980)	no
Tyrophagus putrescentiae (Schrank) (Acarina: Acaridae)	cereal mite	MAFBNZ, 2009	fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (MAFBNZ, 2009; CPC, 2007)	yes (Manson, 1987; Ramsay, 1980)	no
Tyrophagus sp. (Acarina: Acaridae)	mould mite	MAFBNZ, 2009	fruit (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	yes (MAFBNZ, 2009)	unknown	no
NEMATODES							
Helicotylenchus dihystera (Cobb, 1893) Sher, 1961 (Secernentea: Tylenchida: Hoplolaimidae)	common spiral nematode	CPC, 2007	roots (CPC, 2007)	no	yes (CPC, 2007; Li et al, 2006)	yes (Wouts and Yeates, 1994; Knight et al, 1997)	no
Meloidogyne spp. (Secernentea: Tylenchida: Meloidogynidae)	root-knot nematode	Biosecurity Australia, 2005	roots	no	unknown	unknown	no
Paratrichodorus porosus (Allen, 1957) (Adenophorea: Dorylaimida: Trichodoridae)	trichodorid nematode	CPC, 2007; Zhao et al, 2005	roots (Zhao et al, 2005)	no	yes (CPC, 2007; Zhao et al, 2005)	yes (Sturhan et al, 1997; PPIN, 2008)	no
Pratylenchus brachyurus (Godfrey, 1929) (Secernentea: Tylenchida: Pratylenchidae)	root lesion nematode	Jones and Aldwinckle, 1990	roots (Jones and Aldwinckle, 1990)	no	yes (Yin, 1991)	no (not recorded in: Knight et al, 1997; PPIN, 2008)	no

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Pratylenchus coffeae (Zimmermann, 1898) (Secernentea: Tylenchida: Pratylenchidae)	root lesion nematode	Jones and Aldwinckle, 1990	roots (Jones and Aldwinckle, 1990); roots, corms, tubers (CPC, 2007)	no	yes (CPC, 2007; CAB International, 2000b)	no (not recorded in: Knight et al, 1997; PPIN, 2008)	no
Pratylenchus loosi Loof, 1960 (Secernentea: Tylenchida: Pratylenchidae)	root lesion nematode	CPC, 2007	roots (CPC, 2007)	no	yes (CPC, 2007; Wang, 1993)	no (not recorded in: Knight et al, 1997; PPIN, 2008)	no
Pratylenchus penetrans (Cobb, 1917) (Secernentea: Tylenchida: Pratylenchidae)	northern root lesion nematode	CPC, 2007; Jones and Aldwinckle, 1990	roots (Jones and Aldwinckle, 1990)	no	yes (CPC, 2007; CAB International, 2003)	yes (Knight et al, 1997; Trought et al, 1985)	no
Pratylenchus vulnus Allen and Jensen, 1951 (Secernentea: Tylenchida: Pratylenchidae)	walnut root lesion nematode	CPC, 2007; Jones and Aldwinckle, 1990	roots (Jones and Aldwinckle, 1990); roots (CPC, 2007)	no	yes (CPC, 2007; CAB International, 2002b)	yes (Knight et al, 1997; PPIN, 2008; CPC, 2007)	no
Trichodorus sp. (Adenophorea: Dorylaimida: Trichodoridae)	stubby root nematodes	CPC, 2007	roots (Christie, 1953; CPC, 2007)	no	yes (CPC, 2007)	unknown	no
Xiphinema americanum Cobb, 1913 (Adenophorea: Dorylaimida: Longidoridae)	dagger nematode	Jones and Aldwinckle, 1990	roots (Jones and Aldwinckle, 1990; Lownsbery, 1964)	no	yes (CPC, 2007; Luo et al, 2003)	yes (Knight et al, 1997; PPIN, 2008)	no
VIROIDS							
Apple scar skin viroid (genus *Apscaviroid*, family Pospiviroidae)	ASSVd	Han et al, 2003; Kyriakopoulou et al, 2003	spread by budding and grafting (CPC, 2007)	no	yes (CPC, 2007; Han et al, 2003)	no (not recorded in: Pennycook, 1989; Pearson et al, 2006)	no
peach latent mosaic viroid (genus *Pelamoviroid*, family Avsunviroidae)	PLMVd	Hassen et al, 2006	not transmitted by seed in peach (Barba et al, 2007)	no	yes (Han et al, 2003)	no (not recorded in: Pennycook, 1989; Pearson et al, 2006)	no
Pear blister canker viroid (genus *Apscaviroid*, family Pospiviroidae)	PBCVd	Han et al, 2003; Pennycook, 1989	bark and leaves (Hassen et al, 2006); not transmitted by seed (ICTVdb, 2008)	no	yes (Han et al, 2003; Paduch, 2003)	yes (Pennycook, 1989)	no
VIRUSES							

Scientific name	Common name	Associated with *Pyrus* spp. (ref)	Plant part association (all hosts)	Likely to be present on *Pyrus* fruit	Present in China	Present in New Zealand	Potential hazard*
Apple chlorotic leaf spot virus (genus *Trichovirus*, family Flexiviridae)	ACLSV	CPC, 2007; Wang et al, 1994	leaves (Niu et al, 2007); not transmitted by seeds (ICTVdb, 2008)	no	yes (Zhang and Huang, 1990; Wang et al, 1994)	yes (VIDE, 2008; Pearson et al, 2006; Pennycook, 1989)	no
Apple mosaic virus (genus *Ilarvirus*, family Bromoviridae)	ApMV	Pennycook, 1989; Pearson et al, 2006	leaves and whole plant (CPC, 2007); transmitted by root grafting, possibly not transmitted by seeds (ICTVdb, 2008)	no	yes (CPC, 2007; CAB International, 2001b)	yes (Pearson et al, 2006; Pennycook, 1989)	no
Apple stem grooving virus (genus *Capillovirus*, family Flexiviridae)	ASGV	Gong et al, 2002; Zheng et al, 2005	trunk, stems, shoots (Gong et al, 2002); transmitted by budding and grafting (CPC, 2007); transmitted by seeds (ICTVdb, 2008)	yes (*Chenopodium* seeds (ICTVdb, 2008))	yes (Zhang and Huang, 1990; Zheng et al, 2005)	yes (Lister, 1986; Pearson et al, 2006; Pennycook, 1989)	no
Apple stem pitting virus (genus *Foveavirus*)	ASPV	Walker et al, 1990; Kitajima, 1977	leaves (Niu et al, 2007); fruit, woody parts (Jones and Aldwinckle, 1990); not transmitted by seeds (ICTVdb, 2008)	Yes	yes (Zhang and Huang, 1990; VIDE, 2007)	yes (Pearson et al, 2006; Pennycook, 1989)	no
Tobacco mosaic virus (genus *Tobamovirus*)	TMV	CPC, 2007	fruit/pods, growing points, inflorescence, leaves, stems and whole plant (CPC, 2007); transmitted by grafting and by seeds (ICTVdb, 2008)	yes (all hosts (CPC, 2007))	yes (CPC, 2007; Zhang and Huang, 1990)	yes (Pearson et al, 2006; Pennycook, 1989)	no
Tobacco necrosis virus (genus *Necrovirus*, family Tombusviridae)	TNV	CPC, 2007	leaves and stems (CPC, 2007); not transmitted by seed (ICTVdb, 2008)	no	yes (CPC, 2007; Huang et al, 1984)	yes (Pearson et al, 2006; Pennycook, 1989)	no

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Appendix 2. Excluded organisms

In the hazard identification process a number of organisms, although found on fruit and present in China, were considered not likely to be present on the importation pathway (*Pyrus* fresh fruit from China). These were therefore not considered to be potential hazards, and are discussed below:

FUNGI

Alternaria mali

Alternaria mali is commonly an apple pathogen, and Roberts (2005) notes that this species name has been and is currently being applied to a perthotrophic (saprophytic on dead tissues) apple leaf pathogen. The record on pears in Washington by English (1940) may be a misidentification. The further records of Shaw (1973) and Farr and others (1989) seem to have come from this source as *A. mali* is only recorded on *Pyrus* in Washington. It is recorded on *Pyrus calleryana* in Tai (1979); all other hosts are Malus species, e.g. *Malus asiatica*, *M. baccata*, *M. prunifolia* and *M. pumila* in China (Tai, 1979). It has not been recorded on *Pyrus communis*, *P. pyrifolia* or *P. bretschneideri*. *A. mali* is not considered to be a potential hazard in this analysis.

Botryosphaeria berengeriana f.sp. *pyricola*

There have long been doubts about the separate identity of *Botryosphaeria berengeriana* f.sp. *pyricola* and these were highlighted in a datasheet on this fungus published by CABI/EPPO (1997). Much of the literature originates in Japan, where the pathogen has been known as *Physalospora pyricola*. The name *Guignardia pyricola* was proposed for the same organism, but has not been accepted (CABI/EPPO, 1997).

Koganezawa and Sakuma (1984) compared a pathogen "resembling *P. piricola*" with another fungus causing apple fruit rot in Japan, which they call *Botryosphaeria berengeriana*, and concluded that the two fungi are identical morphologically. *B. berengeriana* is usually considered to be a synonym of *B. dothidea*; however, the Japanese authors regarded it as a synonym of *B. ribis* (CABI/EPPO, 1997), and recommended the use of the name *B. berengeriana* instead of *B. ribis* (Koganezawa and Sakuma, 1984).

Because the Japanese isolates of '*P. piricola*', caused distinctly different symptoms on apple bark (wart-like protrusions) from the cankers due to typical *B. berengeriana* (both types also caused fruit rot), Koganezawa and Sakuma (1984) proposed the name *B. berengeriana* f.sp. *pyricola* for the fungus causing apple wart bark. At the time of the CABI/EPPO review (1997), this name had not been used outside Japan. Elsewhere in Asia, the agent of apple ring rot was simply called *B. dothidea*, *B. berengeriana*, or sometimes still *P. pyricola* (CABI/EPPO, 1997). Subsequently, the name *B. berengeriana* f.sp. *pyricola* has also been used several times in publications from China.

Previous studies either have treated *B. dothidea* as the valid name for *B. ribis* and/or *B. berengeriana* or argued for them to be separate entities. For example, Zhang and others (2000) used RAPD analysis to confirm the separation between the two taxa, concluding that the traditional taxonomy of *B. berengeriana* and *B. berengeriana* f.sp. *piricola* was reasonable, and that these two pathogens causing apple (*M. pumila*) canker were different species from that causing poplar canker and cankers of the other species (which were all caused by *B. dothidea*).

Later, Slippers and others (2004) used morphological, cultural and DNA sequence datasets to fully characterise *Botryosphaeria dothidea*, *B. ribis* and *B. berengeriana*, and found that *Botryosphaeria dothidea* was distinct from *B. ribis*, while *B. berengeriana* was retained as synonym of *B. dothidea*.

Shaun Pennycook (Landcare Research, pers. comm. 2008) noted that "almost all references before 2004 can be discounted (to a greater or lesser extent) because they were based on morphology alone (always extremely difficult with *Botryosphaeria*) or early attempts at molecular analyses that did not include the critical discriminatory genes".

Many additional studies have concluded that *Botryosphaeria dothidea* and *B. ribis* are separate species (e.g.Wang et al, 2007).

Farr and others (2008) note that *Botryosphaeria berengeriana* f.sp. *pyricola* is morphologically identical to *B. dothidea* but causes distinct disease symptoms, and that some authors consider it a taxonomic synonym. Ogata and others (2000) used morphological characteristics, disease symptoms and nucleotide sequencing to conclude that isolates of a *Botryosphaeria* species that was common on deciduous fruit trees in Japan as a causal agent of ring rot and wart bark diseases of apples and pears was similar to the *B. dothidea* from the USA that was isolated from apple exhibiting white rot. It is likely that this is the *Botryosphaeria* species was that referred to as *B. berengeriana* f.sp. *piricola* by Koganezawa and Sakuma (1984), and that *B. berengeriana* f.sp. *piricola* is also a synonym of *Botryosphaeria dothidea*. *B. dothidea* is common and widespread in New Zealand (Pennycook, 1989; Landcare NZFUNGI, 2008).

On this basis *Botryosphaeria berengeriana* f.sp. *pyricola* is not considered to be a potential hazard in this analysis.

The name *Macrophoma kawatsukaii* has been used several times in publications from China. It is not recorded from any other country. *Macrophoma kuwatsukai* has been referred to as the anamorph of *B. berengeriana* in east Asia (CABI/EPPO, 1997), and Tai (1979) uses *Physalospora piricola* as a synonym of *M. kawatsukai*. *Physalospora piricola* is the anamorph of *Botryosphaeria berengeriana* f.sp*. pyricola* (Indexfungorum, 2008; CABI/EPPO, 1997) and *Macrophoma kawatsukai* is considered a synonym of this fungus in this analysis.

Corticium centrifugum

Although the taxonomy of *Corticium centrifugum* is confused in the available literature (for example, Indexfungorum (2008) describes this species as being: a) a synonym of *Athelia arachnoidea*, b) a valid species in its own right – *Corticium centrifugum* (Weinm.) Fr. (1874), and c) a synonym of *Athelia rolfsii*). The records for pears in China refer to *C. centrifugum* as a synonym of *Sclerotium rolfsii* (*Athelia rolfsii* (anamorph *Sclerotium rolfsii*)) (Tai, 1979). This name is dealt with as a synonym of *Athelia rolfsii* in this analysis.

Fusicladium pyricola

The only available reference for this fungus is Farr and others (2008), which cites Zhuang (2005). The name is not included in Tai, 1979 and is not mentioned in the *Fusicladium* monograph of Schubert and others (2003). This is likely to be either a rare fungus, of very low importance, or an error. It is not recorded on *Pyrus* sp. nr. *communis*, *P. pyrifolia* or *P. bretschneideri*. Another regulated species of Venturia (*Venturia nashicola*, anamorph

Fusicladium nashicola) is assessed as a hazard in this analysis. *F. pyricola* is not considered to be a potential hazard in this analysis.

***Glomerella cingulata* (anamorph *Colletotrichum gloeosporioides*)**
There are known strains of *Glomerella cingulata* (some not known to be present in New Zealand). However, it has been recorded in *Pyrus* in New Zealand, and as such is not considered a potential hazard in this analysis.

Gymnosporangium asiaticum
CPC (2007) states that fruit are not infected and are not known to carry this pest in trade/transport. A search of CAB abstracts (2008) using all known synonyms found no records of this rust on fruit of any host. Other authors record this rust on leaves and stems (e.g. Jones and Aldwinckle, 1990; Teng, 1996; Farr et al, 2008 and Kern, 1973). Biosecurity Australia (2005) lists this rust fungus as being associated with pears in China, but we can find no evidence for an association with mature fruit. It is therefore not considered a potential hazard in this analysis.

Gymnosporangium clavariiforme
There are few reports of this fungus on *Pyrus* spp. and no reports of it affecting fruit of *Pyrus*. It is particularly a pest of hawthorn (*Crataegus* spp.) where the alternate hosts are in close proximity. Laundon (1977a) noted that some records of this rust on pear are in error. It is unlikely to be associated with pear fruit and is highly unlikely to enter New Zealand on the *Pyrus* fruit from China pathway. It is therefore not considered a potential hazard in this analysis.

Gymnosporangium confusum
Laundon (1977b) states that there have only been rare, weak infections on pear. In addition, some reports of this rust on *Pyrus* are in error; for example, Cummins (1943) recorded it on *Pyrus lanata* (= *Sorbus lanata*). The few reports of *G. confusum* on fruit have mostly been on medlar (*Mespilus germanica*) (e.g. Kheladze and Dvurechenskaya-Tskhvedadze, 1980). There have been no reports of *G. confusum* on fruit of *Pyrus*. *Gymnosporangium confusum* is unlikely to be associated with pear fruit and is highly unlikely to enter New Zealand on the *Pyrus* fruit from China pathway. It is therefore not considered a potential hazard in this analysis.

Gymnosporangium yamadae
Has only been recorded once on *Pyrus*, on *Pyrus betulifolia* (Tai, 1979). It has not been recorded on any of the species of *Pyrus* for which China has requested access (*Pyrus* sp. nr *communis*, *Pyrus pyrifolia* or *Pyrus bretschneideri*), or on *P. communis*. All other records of this rust are on *Malus* or *Juniperus* species, and the record on *P. betulifolia* may be a mis-identification. The only record for an association with fruit relates to apples where it is reportedly rare (Laundon, 1977c). It is therefore not considered a potential hazard in this analysis.

***Penicillium* sp.**
Eight species of *Penicillium* have been recorded on *Pyrus* (*Penicillium aurantiogriseum*, *P. chrysogenum*, *P. crustosum*, *P. expansum*, *P. italicum*, *P. roqueforti*, *P. rugulosum* and *P. sclerotigenum*). All of these are recorded in New Zealand and are non-regulated, except for *P. sclerotigenum*, which is not present in China. The interception recorded in the MAF BNZ interception database (MAFBNZ, 2009) is highly likely to have been of one of these species and it is not considered to be a potential hazard in this analysis.

Phyllosticta solitaria
Phyllosticta solitaria (apple blotch) is found principally on *Malus* spp. (apples), including cultivated forms and the wild *Malus coronaria*, on which the pathogen was first described (CPC, 2007). Other hosts are *Crataegus* spp. (CPC, 2007; Tai, 1979). Records of *Pyrus* spp. as hosts seem to be mainly historical taxonomic synonyms, e.g. *Pyrus malus* (*Malus domestica*) and *Pyrus prunifolia* (*Malus prunifolia*) (Farr et al, 2008). There is no literature in CAB abstracts regarding this fungus as a pathogen of *Pyrus.* It is not considered a potential hazard in this analysis.

Pythium debaryanum
Pythium debaryanum is usually a soil organism, causing root rot, seed rot, and damping-off of seedlings. It can cause a rot of fruit that are in contact with the soil, e.g. eggplants (Roy, 1997). It is not a potential hazard of *Pyrus* fruit (which are not in contact with soil), and is not considered to be a potential hazard in this analysis.

Xylaria carpophila
There are many records of this fungus on the British Mycological Society website on the 'cupules' of *Fagus* spp. (http://www.britmycolsoc.org.uk/). The only reference for an association with 'fruit' in Farr and others (2008) seems to derive from its presence on the cupules of *Fagus* spp. It has never been recorded on *Pyrus* fruit, or any other fleshy fruit. It is not considered to be a potential hazard in this analysis.

INSECTA
Agrotis ipsilon
Agrotis ipsilon is recorded from New Zealand as the subspecies *Agrotis ipsilon aneituma* Walker, 1965 (Dugdale, 1988). The species was originally described from Europe by Hufnagel in 1766 as *Agrotis ipsilon*, and the subspecies recorded from Europe is *A. ipsilon ipsilon*. *Agrotis ipsilon aneituma* is based on a single male specimen from the island of Anietyum (Papua New Guinea), and is said to have an Australasian distribution including Australia, New Zealand and Papua New Guinea (Dugdale, 1988). However, neither Common (1958) nor Dugdale (1988) were able to find any characters to distinguish the putative subspecies, and Edwards (1996) lists *anietuma* (Walker, 1865: Noctua) as a synonym of *ipsilon* (Hufnagel, 1766: Phalaena). Consequently *Agrotis ipsilon* is not considered a potential hazard in this analysis.

Anarsia lineatella
Anarsia lineatella has been recorded on fruit of some hosts. However, in pears, only shoot damage has been observed (CPC, 2007; Sorenson and Gunnell, 1955). Therefore, it is not considered to be a potential hazard in this analysis.

Anthonomus pomorum
Anthonomus pomorum has been recorded as "occasionally feeding on young fruit" by CPC (2007); no source has been found for this statement and it is predominantly a pest of blossoms. The larvae feed on the reproductive organs of the plant and the larval stage lasts 2–3 weeks (Miles, 1923). The flower bud becomes dry and brown, taking on a capped appearance. Pupation is within the flower bud and lasts 5–10 days; the young adult then cuts its way out (Miles, 1923). The young adults feed on the underside of leaves until early summer. They then seek shelter under loose rough bark, in crevices, under curled leaves, stones or leaf litter and enter a long period of dormancy, or aestivo-hibernation, from early summer to early spring (Miles, 1923; Toepfer et al, 2000). No lifestage is likely

to be associated with mature fruit and *A. pomorum* is therefore not considered a potential hazard in this analysis.

Aonidiella orientalis
There is only one record of *Aonidiella orientalis* on *Pyrus* species (on *Pyrus sinensis* in India in 1941) and no rosaceous plants are noted as major hosts. The record on *Pyrus sinensis* is likely to have been *Pseudocydonia sinensis* as the taxonomy of *Pyrus* and *Malus* was somewhat fluid around that time. This insect is unlikely to be associated with mature pear fruit from China and is not considered to be a potential hazard in this analysis.

Brachycaudus helichrysi
Brachycaudus helichrysi is present in New Zealand (Teulon et al, 2004), but is regulated as a vector. *B. helichrysi* is known to transmit viruses, including: Beet mild yellowing virus (ICTVdb, 2008), Beet western yellows virus (ICTVdb, 2008), Cineraria mosaic virus (CPC, 2007), Cucumber mosaic virus (CPC, 2007), Dahlia mosaic virus (CPC, 2007), Plum pox virus (CPC, 2007; ICTVdb, 2008), and Potato virus V (ICTVdb, 2008). None of these viruses are known to affect *Pyrus*. Therefore, *B. helichrysi* is not considered a potential hazard in this analysis.

Ceratitis capitata
Ceratitis capitata is recorded as present in Hubei province China, in two erroneously translated Chinese articles (Lu et al, 2006; Cheng, 2003) on internet databases. This fruit fly has never been found in China and is therefore not considered further in this risk analysis. Monitoring and surveillance programmes in pear producing regions include a lure for *C. capitata* (AQSIQ, 2007); if it is detected in the future, a risk assessment for this species should be conducted.

Ceroplastes rubens
The only reference for an association of *Ceroplastes rubens* with fruit is CPC (2007), which states that 'on *Citrus*, it feeds mainly on leaves, but also on twigs and fruit', citing Sabine (1969). Sabine (1969) does not refer to *C. rubens* on fruit. The mobile early instars (known as crawlers) could walk or be blown onto fruit from infested vegetation. However, since *Pyrus* is not a major host (CPC, 2007), population densities are unlikely to be high and the likelihood of association is considered to be negligible. *C. rubens* is therefore not considered to be a potential hazard in this analysis.

Cicadella viridis
There is only one report of *Cicadella viridis* on "fruit" (Yang, 1994). All other reports are of this organism causing oviposition damage to stems, shoots and branches. The report by Yang (1994) is likely to have been either a transient association or a mis-translation. It has not been recorded on *Pyrus* fruit. *C. viridis* is not considered a potential hazard in this analysis.

***Cryptophagus* sp.**
Members of the genus *Cryptophagus* (fungus beetles) are not known to be phytophagous. An unidentified species of *Cryptophagus* was intercepted on fruit of *Pyrus bretschneideri* from China in 2003 (MAFBNZ, 2009) at the New Zealand border. It is likely that this was a hitchhiker. The genus *Cryptophagus* has been recorded in New Zealand (Leschen et al, 2003). Since the intercepted beetle was not identified it is not possible to undertake a risk assessment. However, if beetles in this genus are intercepted in future further assessment may be required.

Dialeurodes citri

Pyrus is a minor host of *Dialeurodes citri* (CPC, 2007). No records have been found of *D. citri* on *Pyrus* fruit and no information was found of its behaviour on *Pyrus*. On *Citrus,* its primary host, all life stages apart from adults are confined to young leaves (Ulu, 1985; Soylu, 1980). Adults may be associated with fruit, but they are mobile and would be unlikely to remain on the fruit during the harvest and packing process. *D. citri* is not considered a potential hazard in this analysis.

Empoasca vitis

There is only one report of *Empoasca vitis* on “fruit” of citrus (Choi et al, 2000). This is likely to have been a transient association. All other reports are of this organism causing damage to leaves. Furthermore, although Biosecurity Australia (2005) lists it as a pest associated with pears in China, no other record of an association with pears was found in the literature. *Empoasca vitis* is not considered to be a potential hazard in this analysis.

Erthesina fullo

Erthesina fullo is reported as causing fruit loss of jujube by premature drop (Song and Wang, 1993). It is not associated with mature fruit and is not considered to be a potential hazard in this analysis.

Frankliniella occidentalis

Frankliniella occidentalis is present in New Zealand (Fletcher and Workman, 2003), but regulated as a vector. *F. occidentalis* is known to transmit the following viruses: Impatiens necrotic spot tospovirus (Vide, 2007; Persley et al, 2006), Groundnut ringspot tospovirus (Vide, 2007; Persley et al, 2006), Tomato chlorotic spot virus (Persley et al, 2006; Jones, 2005), Tomato spotted wilt virus (Vide, 2007; Persley et al, 2006), Tobacco streak virus (Vide, 2007; Jones, 2005), Chrysanthemum stem necrosis virus (CPC, 2007; Jones, 2005), and Pelargonium flower break virus (CPC, 2007; Jones, 2005). None of these viruses are known to affect *Pyrus*. Therefore, *F. occidentalis* is not considered a potential hazard in this analysis.

Holotrichia parallela* and *Holotrichia titanis

In Shandong, China, *Holotrichia parallela* is the main insect pest of groundnuts (peanuts). Third-instar larvae are present from mid-August and feed on the nuts (Zhao, 1983). There is little information available on the biology of *Holotrichia titanis*, but *Holotrichia* spp. are scarabid beetles whose larvae generally feed on roots, although adults also feed on leaves (e.g. Kapadia et al, 2006). AQSIQ (2007) reports *H. parallela* as an infrequent pest on *Pyrus bretschneieri* and *P. pyrifolia.* AQIS (1998) list both *H. parallela* and *H. titanis* as quarantine pests on *Pyrus bretschneieri* from China. However no evidence has been found in the literature of either species being associated with *Pyrus* fruit. Therefore, neither species are considered to be potential hazards in this analysis.

Lepidosaphes kuwacola

L. kuwacola is recorded in Japan (AEI, 2008). ScaleNet (2008) records it as present in China (Sichuan); citing Tao (1999) who records it as *Cornimytilus kuwacola* (synonym *Lepidosaphes ume*), citing Kuwana, 1925 who does not mention Sichuan and treats *L. kuwacola* and *L. ume* as separate species. Given that *L. kuwacola* is otherwise only recorded in Japan, it is assumed that there has been a mistranslation of the record for Sichuan (a landlocked, western province of China). No records of it infesting fruit were found, although other species in the same genus are present on fruit. It is not considered a potential hazard in this analysis.

Lygocoris lucorum
Lygocoris lucorum has been recorded on fruit of grapes, although it is primarily found on the young shoots and leaves of host plants. Biosecurity Australia (2005) lists it as associated with *Pyrus*, but no evidence of an association has been found in the literature. Therefore it is not considered a potential hazard in this analysis.

Macrosiphum euphorbiae
Macrosiphum euphorbiae is present in New Zealand (Teulon et al, 2004), but is a vector of over 40 non-persistent viruses and five persistent viruses (CPC, 2007). Of the nine viruses known to affect *Pyrus* species (Apple chlorotic leaf spot virus, rus, Carnation ringspot virus, pear bark measles, Tobacco mosaic virus, Tobacco necrosis virus and Tomato bushy stunt virus), none are known to be transmitted by *M. euphorbiae* (ICTVdb, 2008; CAB abstracts checked 17/4/08). Therefore, *M. euphorbiae* is not considered a potential hazard in this analysis.

Myzus persicae
Myzus persicae is present in New Zealand (Teulon et al, 2004), but regulated as a vector. It is known to transmit approximately 100 viruses (CPC, 2007; ICTVdb, 2008; VIDE, 2008). None of these viruses are known to affect *Pyrus*. Therefore, *M. persicae* is not considered a potential hazard in this analysis.

Parlatoria proteus
Parlatoria proteus is polyphagous and has been recorded from hosts belonging to 122 genera in 22 plant families. Palms and orchids are favoured hosts. *Pyrus communis* and *P. serotina culta* (= *Pyrus pyrifolia*) are listed among the hosts (ScaleNet, 2008). Original sources for *Pyrus* spp. being a host do not provide robust evidence of an association with fruit of *Pyrus* spp. *P. proteus* is therefore not considered a potential hazard in this analysis.

Parlatoria pergandii
Pyrus is not listed amongst the hosts (AEI, 2008; ScaleNet, 2008; CPC, 2007) of *Parlatoria pergandii*. The record on pear in Spiller and Wise (1982) is a misidentification of *P. desolator*. Charles and Henderson (2002) state that: "this species was recorded by Maskell from Hong Kong on orange, and was apparently intercepted at quarantine in the United States from citrus shipped via New Zealand (Morrison, 1939). All other records from New Zealand are based on misidentifications of *P. desolator* (Henderson, 2000) including those on apple and pear recorded in Spiller and Wise 1982". Ehrhorn (1925) reported that *Parlatoria pergandii* was intercepted in Hawaii in 1925 on sand-pears (*Pyrus sinesis*) from Japan. There was an interception record for an unidentified *Parlatoria* on pears from India (MAFBNZ, 2009). Tao and others (2004) reported that in peach, apple and pear orchards in Kunming, China, *P. pergandii* mainly attacked host branches, with nymphs and female adults feeding on the sap of the host. Since both crawlers and males are dispersal stages, even though there is no biological association with pear fruit, it is possible for these life stages to occur on fruit by chance. This may be the basis for the Hawaiian interception. However, if they do not feed on fruit, they are likely to move off the fruit to find suitable host material and the likelihood of association with harvested fruit would be remote. *P. pergandii* is not considered a potential hazard in this analysis.

Proeulia chrysopteris
Proeulia chrysopteris has been recorded on *Pyrus*, and is associated with the fruit and flowers of host plants. It has been reported from China (Zhang, 1994). However Brown

and Passoa (1998) state that this record is almost certainly based on a mis-determination. The only other reported locality for *P. chrysopteris* is Chile (CPC, 2007; Parra and Cerda, 1992; Zhang, 1994). It is assumed that *P. chrysopteris* is not present in China and therefore is not considered to be a potential hazard in this analysis.

Pseudococcus longispinus

Pseudococcus longispinus is present in New Zealand (Scott and Emberson, 1999, Spiller and Wise, 1982), but is regulated as a vector. It is known to vector Grapevine leafroll-associated virus types 1-5 (CPC, 2007; ICTVdb, 2008), Grapevine virus A (CPC, 2007; ICTVdb, 2008), Cacao swollen shoot virus (mampong strain only) (ICTVdb, 2008), and Vitivirus (ICTV database, 22 Apr 2008). The mealybug is also associated with stem pitting in grapevines (Rosciglione and Gugerli, 1986). In the south-west Pacific region, *P. longispinus* is also a vector of the smaller of two bacilliform viruses causing ‘bobone’ disease in some cultivars of taro (*Colocasia esculenta*) and *Xanthosoma* sp. (Gollifer et al, 1997). None of these viruses are known to affect *Pyrus*. Therefore, *P. longispinus* is not considered a potential hazard in this analysis.

Rhynchites coreanus* and *Rhynchites foveipennis

Rhynchites coreanus and *R. foveipennis* have been treated as synonyms of *Rhynchites heros* (Biosecurity Australia, 2008). There is little information on either of these names and we assume that they are synonyms of *Rhynchites heros* which is assessed in Chapter 6.

Stephanitis nashi

In Shandong, *Stephanitis nashi* is regarded as one of the main pests in pear orchards (Bao et al, 2001). AQSIQ (2007) states that it occurs frequently on *Pyrus bretschneideri*, *P. pyrifolia* and *P*. sp. nr. *communis*. The eggs of *Stephanitis* species are inserted into the spongy mesophyll of the host plant (Neal and Schaefer, 2000). Lace bugs reside on the lower surface of the leaves of their hosts. Nymphs and adults feed on the leaves (Neal and Schaefer, 2000). Biosecurity Australia (2005) list *Stephanitis nashi* as a quarantine pest on pears from China. However no evidence has been found in the literature of this species being associated with *Pyrus* fruit. Therefore, it is not considered to be a potential hazard in this analysis.

***Spilogona* sp.**

Members of the genus *Spilogona* are not known to be phytophagous. It is likely that the unidentified individual of *Spilogona* intercepted with Ya pear fruit from China in 2000 (MAFBNZ, 2009) was a hitchhiker. At least 29 species of *Spilogona* are recorded as present in New Zealand, although these are endemic so will not be the same species as intercepted (Macfarlane et al, 2000). Since the intercepted fly was not identified it is not possible to undertake a risk assessment. However, if flies in this genus are intercepted in future further assessment may be required.

Tessaratoma papillosa

Pyrus spp. are reported to be minor hosts of *Tessaratoma papillosa* (CPC, 2007). It has been recorded on the fruit of litchi (Zhang, 1997). However, it is usually associated with the stems of host plants, and causes fruit drop by sucking the sap of flowering and fruiting shoots (CPC, 2007). There is no evidence that it is associated with mature pear fruit and it is not considered a potential hazard in this analysis.

Toxoptera odinae

Toxoptera odinae is primarily associated with the leaves and shoots of host plants (CPC, 2007; Martin, 1989), although it has been recorded on the nuts and 'fruit' of coffee (CPC, 2007). *T. odinae* is predominantly associated with tropical trees and shrubs, especially mango and cashew nuts. Although Blackman and Eastop (2000) state that *T. odinae* feeds on *Pyrus,* no other literature indicating that any member of the Rosaceae is a host has been found. It is not considered a potential hazard in this analysis.

Thrips tabaci

Thrips tabaci is present in New Zealand (Fletcher and Workman, 2003), but regulated as a vector. *T. tabaci* is known to transmit the following viruses: Iris yellow spot virus, Maize chlorotic mottle virus, *Prunus* necrotic ringspot virus, Sowbane mosaic virus, Tobacco streak virus, Tomato spotted wilt virus (Jones, 2005) and Tobacco ringspot virus (Brunt et al, 2007). None of these viruses are known to affect *Pyrus*. Therefore, *T. tabaci* is not considered a potential hazard in this analysis.

Xylotrupes gideon

Adults of *Xylotrupes gideon* have been recorded feeding on pineapple, longan and lychee fruit in coastal Queensland (Waite and Elder, 2005), but they are reportedly confined to the bark of apple and pear trees (Sirinthip and Black, 1987). Eggs are laid in rotting organic matter.

The larvae usually feed on decaying organic matter in the soil (Mishra, 1995), and in the process may damage roots (Waite and Elder, 2005). The adult beetles feed above ground, predominantly on the soft bark of young shoots of many trees (Monteith, 2000). *Xylotrupes gideon* is not likely to be associated with the commodity and is not considered a potential hazard in this analysis.

MITES

Tetranychus urticae

Tetranychus urticae is present in New Zealand (Ramsay, 1980; Manson, 1987; Zhang et al, 2002), but was previously regulated as a vector. It has been previously recorded as a vector of Cucumber mosaic virus, Tobacco ringspot virus, Tobacco mosaic virus, Bean southern mosaic virus, and Cotton curliness (citing Jeppson et al, 1975). However, this mite has since been proven repeatedly to not be a vector of these, and other, plant viruses (CAB Abstracts searched, 06 Aug 2007; CPC, 2007; Vide Database, 2007). Therefore, *Tetranychus urticae* is not considered a potential hazard in this analysis.

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Appendix 3. Glossary of definitions and abbreviations

a.i.	active ingredient
Anamorph	The asexual form (also called the imperfect state) of a fungus; characterised by asexual spores (e.g. conidia) or the absence of spores. [‘sexual’ state – see Teleomorph) (Kirk et al, 2001)]
area	An officially defined country, part of a country or all or part of several countries, as identified by the competent authorities
ascospore	[of fungi] A sexual spore borne in an ascus. Typically eight ascospores are produced per ascus (Kirk et al, 2001)
ascus (pl. asci)	The typically sac-like cell, characteristic of the fungal phylum Ascomycota, in which ascospores (generally eight) are produced by free cell formation (Kirk et al, 2001)
BSA	Biosecurity Act 1993
commodity	A good being moved for trade or other purposes. Packaging, containers, and craft used to facilitate transport of commodities are excluded unless they are the intended good.
conidium (pl. conidia)	Asexual spore of a fungus (Kirk et al, 2001)
consequences	The adverse effects or harm as a result of entry and establishment of a hazard, which cause the quality of human health or the environment to be impaired in the short or longer term.
contact fungicide	A fungicide that remains on the surface where it is applied but does not go deeper; these fungicides have no after-infection activity (http://www.ipm.iastate.edu/ipm/icm/2006/5-15/fungicides.html).
CPC	Crop Protection Compendium (internet database)
culm	the above-ground or aerial stems of grasses and sedges.
cupule	part of the accessory fruit of flowering plants in the family Fagaceae e.g. the cup-shaped structure of hardened bracts at the base of an acorn
disease	A finite abnormality of structure or function with an identifiable pathological or clinicopathological basis, and with a recognizable syndrome of clinical signs. Its cause may not be known, or may be from infection with a known organism.
eclosion	The emergence of an adult insect from its pupal case, or the hatching of an insect larva from an egg.
endemic	Endemic in biology and ecology means exclusively native to a place or biota. It is in contrast to any one of several terms meaning “not native” (e.g., adventive, exotic, alien, introduced, naturalized, non-native).

	However, it is also differentiated from indigenous. A species that is endemic is unique to that place or region, found naturally nowhere else. A species that is indigenous is native, but not unique because it is also native to other locations as well.
entry	(of an organism or disease) Movement of an organism or disease into a risk analysis area.
environment	(Biosecurity Act 1993) Includes: (a) ecosystems and their constituent parts, including people and their communities; and (b) all natural and physical resources; and (c) amenity values; and (d) the aesthetic, cultural, economic, and social conditions that affect or are affected by any matter referred to in paragraphs (a) to (c) of this definition.
establishment	Perpetuation, for the foreseeable future, of an organism or disease within an area after entry.
exotic	This word has different meanings in different fields, but in this document is defined as an animal, plant, pest or disease that is not indigenous to New Zealand.
exposure	The point where a contaminating organism becomes associated with a host in New Zealand in a manner that allows the organism to complete a normal life cycle.
hazard	Any disease or organism that has the potential to produce adverse consequences.
heteroecious	undergoing different parasitic stages on two unlike hosts (Kirk et al, 2001)
hitch-hiker pest	A species that is sometimes associated with a commodity but does not feed on the commodity or specifically depend on that commodity in some other way.
IHS	Import Health Standard
Import Health Standard (IHS)	A statement approved under section 22 of the Biosecurity Act 1993 by a chief technical officer of the conditions that must, if an import is to be made, be met in the country of origin or export, during transit, during importation and quarantine, and after introduction.
Import Risk Analysis	A process to identify appropriate risk-mitigating options for the development of import health standards. These risk analyses can focus on an organism or disease, a good or commodity, a pathway, or a method or mode of conveyance such as shipping, passengers or packaging.
indigenous	A species that occurs naturally in an area; native. Organisms occurring naturally in a designated geographical area, but also elsewhere (differentiated from endemic).

introduced Organism not originally from the country it is found in, arrived there by human activity whether deliberate or accidental.

IRA Import Risk Analysis

ISTA International Seed Testing Association

MAF The New Zealand Ministry of Agriculture and Forestry.

MAFBNZ MAF Biosecurity New Zealand

measure A measure may include all relevant laws, decrees, regulations, requirements and procedures including, inter alia, end product criteria; processes and production methods; testing, inspection, certification and approval procedures; quarantine treatments including relevant requirements associated with the transport of risk goods, or with the materials necessary for their survival during transport; provisions on relevant statistical methods, sampling procedures and methods of risk assessment; and packaging and labelling requirements directly related to biosecurity.

National Plant Protection Organisation Official service established by Government to discharge the functions specified by the IPPC. [FAO, 1990; formerly Plant Protection Organisation (National)].

notifiable organism An organism that has been declared under the Biosecurity Act (1993) to be a notifiable organism for New Zealand or a region or regions of New Zealand.

NPPO National Plant Protection Organisation.

organism (Biosecurity Act 1993) (a) Does not include a human being or a genetic structure derived from a human being: (b) Includes a micro-organism: (c) Subject to paragraph (a) of this definition, includes a genetic structure that is capable of replicating itself (whether that structure comprises all or only part of an entity, and whether it comprises all or only part of the total genetic structure of an entity): (d) Includes an entity (other than a human being) declared by the Governor-General by Order in Council to be an organism for the purposes of this Act: (e) Includes a reproductive cell or developmental stage of an organism: (f) Includes any particle that is a prion.

pathway Any means that allows the entry or spread of a potential hazard.

perithecium (pl. perithecia) [of fungi] A flask-shaped or sub-globose ascoma (an ascus-containing structure; ascocarp) with an ostiole (pore by which spores are freed). (Kirk et al, 2001)

pest risk assessment A process to measure the level and nature of biosecurity risk posed by an organism. A pest risk assessment can be used to inform biosecurity surveillance activities or identify pests of high risk to New Zealand.

pest	Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products [FAO, 1990; revised FAO, 1995; IPPC, 1997] Note: For the purpose of this standard "pest" includes an organism sometimes associated with the pathway, which poses a risk to human or animal or plant life or health (SPS Article 2).
pest-free area	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained [FAO, 1995].
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 [ISPM No. 10, 1999].
phytosanitary certificate	Certificate patterned after the model certificates of the IPPC [FAO, 1990]. The certificate must follow the pattern set out in the model phytosanitary certificate, ISPM No. 12 (2001), "Guidelines for phytosanitary certificate". The certificate is issued by the exporting country's NPPO, in accordance with the requirements of the IPPC, to verify that the requirements of the relevant import health standard have been met.
PPIN	Plant Pest Information Network database (MAF database).
MAFBNZ 2009	MAFBNZ Analysis and Profiling Group's database of commercial consignments and interceptions of pests made by quarantine inspection.
regulated pest	A pest of potential economic importance to New Zealand and not yet present here, or present but either not widely distributed and being officially controlled, having the potential to vector another organism, or a regulated non-quarantine pest.
residual risk	The risk remaining after risk management requirements have been implemented.
risk analysis area	The area in relation to which a risk analysis is conducted.
risk analysis	The process composed of hazard identification, risk assessment, risk management and risk communication.
risk assessment	The evaluation of the likelihood, and the biological and economic consequences, of entry, establishment, or exposure of an organism or disease.
risk management	The process of identifying, selecting and implementing measures that can be applied to reduce the level of risk.
risk	The likelihood of the occurrence and the likely magnitude of the consequences of an adverse event.
seed borne pathogen	Any infectious agent associated with seeds that has the potential of causing a disease of a seedling or plant, including all plant-

pathogenic bacteria, fungi, nematodes and other micro-organisms, and viruses, all of which can be carried in, on or with seeds.

seed borne Carried from one place to another in, on, or with seed.

seed infection The establishment of a pathogen within any part of a seed, which may occur systematically, either through the plant vascular system or directly through floral infection or penetration of the ovary wall, seed coat or natural openings.

seed infestation or contamination The passive association of a pathogen with seeds. The pathogen may adhere to the surface or be mixed with seeds.

seed transmission The passage of a seedborne pathogen from seeds to seedlings and plants.

seed A unit of reproduction used for sowing. This includes spores but excludes vegetative propagules.

spread Expansion of the geographical distribution of a potential hazard within an area.

systemic fungicide A fungicide that is absorbed into plant tissue and may offer some after-infection activity. Very few fungicides are truly systemic (i.e., move freely throughout the plant); however, some are upwardly systemic (i.e., move only upward in the plant through xylem tissue), and some are locally systemic (i.e., move into treated leaves and redistribute to some degree within the treated portion of the plant (http://www.ipm.iastate.edu/ipm/icm/2006/5-15/fungicides.html).

teleomorph The sexual form (also called the perfect state) of a fungus; characterised by the production of sexual spores (e.g. ascospores). 'Sexual' spores are those produced after a nuclear fusion followed by meiosis. [asexual state – see Anamorph] (Kirk et al, 2001)

telium (pl. telia) a sorus producing teliospores (Kirk et al, 2001)

univoltine Having one generation per year

unwanted organism (Biosecurity Act 1993) Means any organism that a chief technical officer believes is capable or potentially capable of causing unwanted harm to any natural and physical resources or human health; and (a) includes: (i) any new organism if the Authority has declined approval to import that organism; and (ii) any organism specified in the Second Schedule of the Hazardous Substances and New Organisms Act 1996; but (b) does not include any organism approved for importation under the Hazardous Substances and New Organisms Act 1996, unless: (i) the organism is an organism which has escaped from a containment facility; or (ii) a chief technical officer, after consulting the Authority and taking into account any comments made by the Authority concerning the organism, believes that the organism is capable or potentially capable of causing unwanted harm to any natural and physical resources or human health.

vector	An organism that carries disease-causing micro-organisms from one host to another. For example, aphids can be transmitters of plant viruses.