Import Risk Analysis:
Table grapes (*Vitis vinifera*) from China

Final

Vitis vinifera

30 October 2009

ISBN 978-0-478-35725-7 (Print)
ISBN 978-0-478-35726-4 (Online)

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Policy and Risk
MAF Biosecurity New Zealand

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Approved for general release

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Executive summary

The People's Republic of China has requested access for the export of fresh table grapes to New Zealand. This has the potential to introduce exotic pests and diseases into New Zealand. The analysis of the biosecurity risks has therefore been completed.

The analysis considers the biosecurity risks of importing into New Zealand, for consumption, table grape bunches (*Vitis vinifera*) that have been produced in China. The commodity definition "table grapes" or "table grape bunches" includes berries, pedicel and peduncle, but without tendrils, stems, leaves, roots or any other plant parts. Options for managing the risks from organisms identified as biosecurity hazards are presented. These options will form the basis for the measures required in a new Import Health Standard for importing table grapes (*V. vinifera*) for consumption, from China into New Zealand. Table grapes for export are produced and packed in China in accordance with commercial packing processes managed by the Chinese inspection and quarantine authority. These processes are taken in to account in the risk assessments for potential hazards.

The following table (Table 1) provides possible risk management options for each identified hazard organism.

Table 1. Summary of possible risk management options for identified hazards on table grapes from China

Hazard organism: organism type and scientific name (page number given in brackets)	Measures that could be considered options for the management of biosecurity risks subject to effective implementation.[1]
Alternaria viticola (p204) *Pilidiella diplodiella* (p209) *Guignardia bidwellii* (p214)	• Pest free place of production, **or** • In-field control and surveillance, **or** • Bagging **and** Phytosanitary visual inspection
Monilinia fructigena (p220)	• Pest free place of production, **or** • In-field control and surveillance, **and** • Bagging **and** Phytosanitary visual inspection
Bactrocera dorsalis (p45) *Drosophila suzukii* (p54)	• Pest free place of production, **or** • Methyl bromide fumigation followed by cold treatment, **or** • Cold treatment
Scirtothrips dorsalis (p173)	• Pest free place of production, **or** • Methyl bromide fumigation **and** Phytosanitary visual inspection • *Cold treatment and SO_2
Brevipalpus lewisi (p186)	• Pest free place of production, **or** • Methyl bromide fumigation followed by cold treatment, **or** • Methyl bromide fumigation
Apolygus lucorum (p66) *Nippoptilia vitis* (p137)	• Pest free place of production, **or** • Bagging **and** Phytosanitary visual inspection, **or** • Methyl bromide fumigation
Latrodectus mactans (represents other *Latrodectus* spp.) (p231)	• Pest free place of production, **or** • Bagging **and** Phytosanitary visual inspection, **or** • *SO_2 fumigation
Harmonia axyridis (p34) *Coccinella transversalis* (p34)	• Bagging, **and** Phytosanitary visual inspection, **or** • Methyl bromide fumigation
Conogethes punctiferalis (p111)	• Bagging **and** Phytosanitary visual inspection, **or** • Methyl bromide fumigation combined with cold treatment

Hazard organism: organism type and scientific name (page number given in brackets)	Measures that could be considered options for the management of biosecurity risks subject to effective implementation.[1]
Eupoecilia ambiguella (p124)	• Bagging and Phytosanitary visual inspection • Methyl bromide fumigation • *Cold treatment and SO_2
Maconellicoccus hirsutus (p73) *Pseudococcus maritimus* (p94)	• Pest free place of production, or • Bagging and Phytosanitary visual inspection, or • Methyl bromide fumigation • *Cold treatment and SO2
Rhipiphorothrips cruentatus (p166)	• Pest free place of production, or • Methyl bromide fumigation
Tetranychus kanzawai (p193)	• Pest free place of production, or • Methyl bromide fumigation combined with cold treatment, or • Methyl bromide fumigation • *Cold treatment and SO_2

[1] For specific conditions see options in the pest risk assessments

* There are indications that this treatment may be useful, however, the effective dose for the species identified as hazards is not known. It is an option that warrants further investigation.

1 Risk analysis background and process

1.1 Background

China has requested access for the export of fresh table grapes to New Zealand. This has the potential to introduce exotic pests and diseases into 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 table grape bunches (*Vitis vinifera*) produced in China for consumption into New Zealand, and identifies options for measures to manage the identified risks. The identified options for measures will then form the basis for a new import health standard for importing table grapes (*V. vinifera*) from China into New Zealand.

For the purposes of this analysis, the commodity description “table grapes” or “table grape bunches” includes grapes, pedicel and peduncle, but without tendrils, stems, leaves, roots or any other plant parts (see **Error! Reference source not found.**). The table grape bunches should be free of any other plants, plant products or regulated weed seeds as specified by MAF in the “Schedule of regulated weed seeds” and therefore detailed risk assessment of these was not included in the scope of this risk analysis. The likelihood of seed-transmitted pathogens entering New Zealand through table grapes is considered to be negligible (see 2.1.6 Grapevine reproduction) and seed-transmitted pathogens are therefore excluded from the scope of this risk analysis.

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.

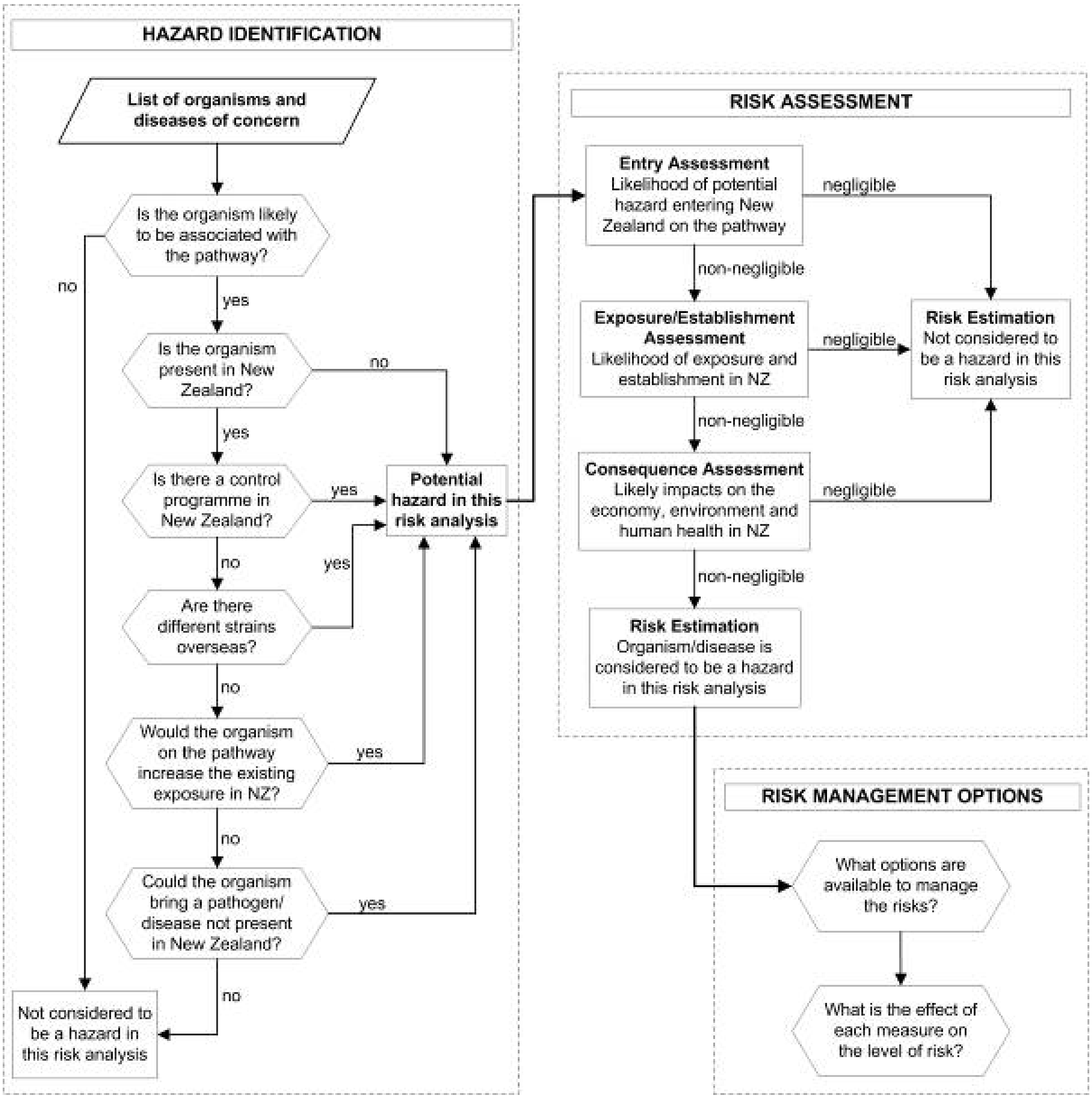
1.3.1 Commodity and pathway description

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 such as 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 hazard identification and risk assessment stages are summarised, and analysed 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 replacing the assumptions with factual evidence.

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, risk management options available for managing the risk are identified. 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 obligated 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 the peer review has been completed the risk analysis is published and released for public consultation. The period for public consultation is usually 6 weeks from the date of publication of the draft risk analysis. All submissions received will be analysed and compiled into a review of submissions. Either a document will be developed with the results of the review and any proposed modifications to the draft risk analysis or the draf risk analysis itself will be edited to comply with the proposed modifications. The risk analysis is finalized.

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/regs/imports/ihs/risk.

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

For the purpose of this risk analysis, table grapes (berries, pedicel and peduncle, but no stems or leaves, see **Error! Reference source not found.**) are assumed to be from anywhere in China. The commodity is assumed to have been inspected in accordance with appropriate official procedures, and found to be free of any other plants, plant products or regulated weed seeds as specified by MAF in the "Schedule of regulated weed seeds".

2.1.1 Taxonomy description

Grapevine originated in Asia Minor, in the region between, and to the south of, the Black and Caspian seas. Grapevine belongs to the family Vitaceae, which is made up of 12 genera and about 600 species. Within the family Vitaceae, the genus *Vitis* is the only genus that includes food plants. More than 90% of the total world production of grapes is from *Vitis vinifera* L. and the world production of grapes exceeds that of any other fruit (Bose *et al*, 2001). This risk assessment covers only grapes from *Vitis vinifera* species.

The common grapevine is a liana with a flaky bark. The vine has a weak stem, branching with long shoots from which secondary shoots develop. When the grapevine is young the trunk is very pliable and must be supported (Bose *et al*, 2001). Tendrils (**Error! Reference source not found.**) assist it to hold on to other structures (May, 2000). The height of the trunk varies depending on the grape variety and can range from 10 cm to 10 m (Robinson, 2006). The leaves are alternate, lobed and broad. The size of the leaves varies with the grape variety, but the typical size is comparable to a human hand. Flowers form branched clusters of one to three per shoot. Most domesticated vines have hermaphrodite flowers. The fruit is a fleshy berry, also known as a grape. In cultivated grapevine plants it is white or red and up to 3 cm long (Bose *et al*, 2001; CPC, 2007: accessed 18/11/2008). All extant white cultivars of grapevine have a common origin. The phylloxera insect devastated European wine production in a matter of years in the late 19^{th} century (Robinson, 2006); therefore, vines these days are mostly grafted on phylloxera-resistant root stocks, originating from American wild species (CPC, 2007; Bose *et al*, 2001).

2.1.2 Grapevine annual cycle

Grapevine cultivation in vineyards follows an annual growth cycle. The cycle starts in spring with bud break, when daily temperatures exceed 10°C (Bose *et al*, 2001). In the northern hemisphere (NH) this is around March, while in the southern hemisphere (SH) it begins around September. In warm climates, after about four weeks the growth of the shoots rapidly accelerates (Robinson, 2006).

Depending on temperature, about 40 to 80 days after bud break the process of flowering begins with small flower clusters appearing. The process of berry set is influenced by climate, planting methods and vineyard management (Okamoto, 2001). Flowering occurs when daily temperatures are between 15 and 20°C (NH: around May; SH: around November). A few weeks later the flowers grow in size and individual flowers become visible and are pollinated (mostly self-pollinated) and fertilised (Bose *et al*, 2001). Grape berries form, containing one to four seeds that are brown and hard at maturity. Several cultivars have seedless berries.

Fruit set, which follows directly after flowering (NH: May; SH: November), determines the potential crop yield, with the average percentage of fertilised flowers varying around 30% (Robinson, 2006).

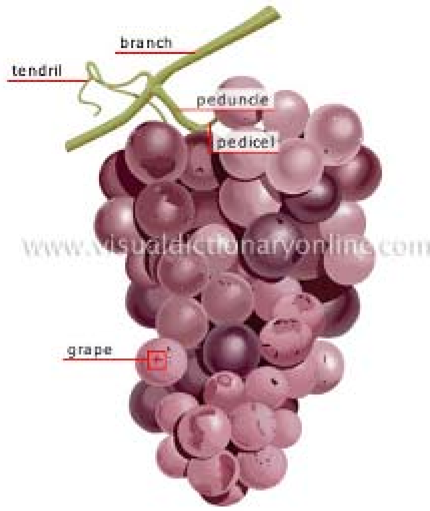
Following fruit set, the grape berries are green and hard. When they are about half their final size, they enter veraison (that is, the transition from berry growth to berry ripening) (Robinson, 2006; Bose *et al*, 2001). The ripening process takes place about 40 to 50 days after fruit set (NH: July/August: SH: January/February) (Bose *et al*, 2001) resulting in the grapes turning red/black or yellow/green depending on the variety. This colour change is caused by the replacement of chlorophyll in the skin by anthocyanins (red grapes) or carotenoids (white grapes) (Bose *et al*, 2001; Robinson, 2006). During the next six days the berries grow dramatically because of the accumulation of glucose and fructose. Berries on the outer part of the canopy undergo veraison first, because they are exposed to more warmth (Robinson, 2006).

Harvest is generally around September/October in the northern hemisphere and March/April in the southern hemisphere. Table grapes are harvested by hand (CPC, 2007). Grapes do not ripen after they are harvested, so berries are left on the vine until they are fully ripe (Bose *et al*, 2001).

2.1.3 Table grape appearance

Table grapes are usually grown in hot, arid areas in order to ensure aesthetically pleasing bunches and to reduce pesticide residues on berries (CPC, 2007). The grapes require long, warm-to-hot, dry summers and cool winters (Bose *et al*, 2001). The grapevine requires support for the shoot in order to ensure good exposure of leaves to the sun. For table grapes, it is preferable to protect bunches from sunburn and to let them hang free (CPC, 2007). Appearance is the most important factor for the sale of table grapes (Bose *et al*, 2001).

Figure 2. Bunch of grapes



2.1.4 Table grape commodity

A cluster of grapes (a bunch) consists of a peduncle and a main axis (rachis), with more-or-less numerous long ramifications on which are inserted small stems (pedicels) that carry the berries (Figure 2; Meneghetti *et al*, 2006; Bose *et al*, 2001). The imported commodity is expected to include grapes, pedicels and peduncle, but not branches, leaves or tendrils.

2.1.5 Grape architecture and packaging

The relatively complex architecture of the grape bunch means that organisms, especially if small, are more likely to escape detection when hidden inside the bunch than organisms on a commodity with a more simple shape such as pipfruit or stonefruit. In addition, insects are rarely distributed randomly but are usually aggregated to some extent, so that if one occurs in a shipment it is quite likely that there will be others. As part of the harvest, processing, and packing procedures for table grapes from China (Section 2.2.2, Import pathway), individual grape bunches are packed into plastic bags at the packing facility after airbrushing and grading inspection. The grape bunches remain in their individual packaging until bought by the consumer which will reduce the likelihood of any hidden organisms from moving to another bunch.

2.1.6 Grapevine reproduction

Grapevines have the potential to be grown from seeds in seeded varieties of grapes bought from the supermarket. Grapevines originated in the cool temperate zone, so the seeds have evolved to undergo a period of winter dormancy before germination. Dormancy can be broken through exposure to a period of low temperature (stratification) of at least 12 weeks at temperatures of 0 to 4 °C (Grapebreeders.org, 2008: accessed 24/11/2008). Within New Zealand, only a limited number of places have three months of average earth temperatures below 4°C and none have more than three months (NIWA, 2008). Grape harvest in China starts at the end of August (Papademetriou and Dent, 2000), which is also at the end of the cold period in New Zealand (NIWA, 2008) (accessed 17/11/2008). Therefore, by the time the grapes are in New Zealand, they will not germinate if discarded in compost or soil, and will only germinate when planted if they are deliberately and artificially stratified (held at low temperature) beforehand. After three months the seeds need day-time temperatures of ~20 ºC to grow further. Therefore, grapes bought in the supermarket and subsequently planted or discarded in soil in New Zealand would be unlikely to germinate or, equally, unlikely to grow if they did germinate.

There is no information on whether consumers ever deliberately stratify and plant grape seeds from table grapes with the intention of growing a grape vine. However, growing grapes from seeds is not the ideal way of reproducing grapevine as the genetic makeup of a variety is not completely carried over by the seeds (My-grape-vine.com, 2008: accessed 24/11/2008). Moreover, grapevine plants grown from seed take two to five years before they initiate flowering (Meneghetti *et al*, 2006). Most grape planting material is propagated by cuttings and consequently seed stratifying is not considered to occur in any significant amount.

For these reasons, the likelihood of seed-transmitted pathogens entering New Zealand through table grapes is considered to be negligible. Organisms or disease that can be transmitted only by seed are therefore excluded from the potential hazard list.

2.2 Pathway description

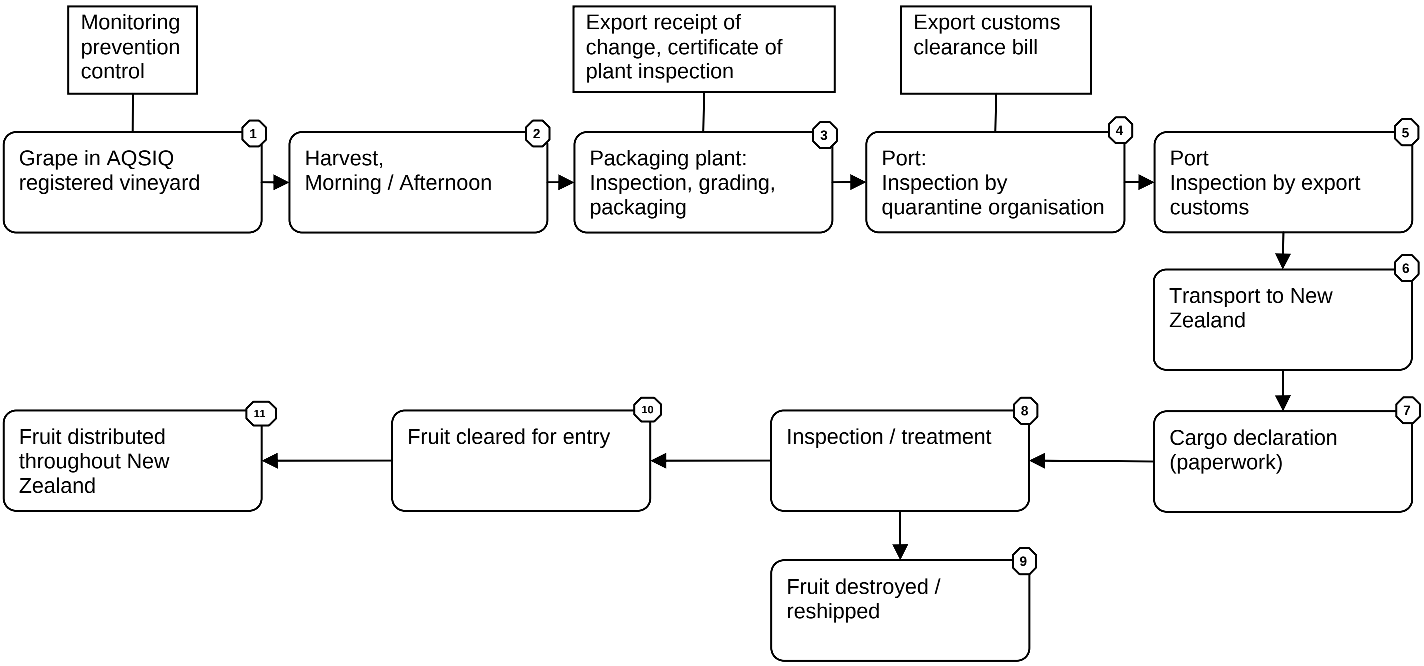
2.2.1 Commodity production

In 2006, China's viticulture area was 483 000 hectares with an output of 6 370 000 tons. The total viticulture area was ranked sixth in the world, while the output was fifth. The grape production is mainly table grapes, with an annual output of 34.7% of the total quantity of the world table grapes (AQSIQ, 2007). The main varieties of table grapes include Kyoho grape, Muscat Hamburg grape, Redglobe, seedless white grape and seedless red grape (AQSIQ, 2007). Other varieties grown in China include: Thompson seedless, Khoussaine Blanc, Hetain Hongputao, Zingzaojing, Zoushan-1, Gongrong-1, Gongrong-2, Chaugbei-9, Campbell Early, Longyan, Zana, Rkastiteli, Italian Riesling, French Blue, Carignane, White Riesling, Beichuu, Red Italia and Tengnian (Bose *et al*, 2001).

2.2.2 Import pathway

An overview of the potential import pathway of table grapes from China to New Zealand is shown in Figure 3.

Figure 3. Potential import pathway for fresh grapes from China into New Zealand



1. All grapes that are to be exported from China are grown in vineyards with registration with the general Administration for Quality Supervision and Inspection and Quarantine of the People's Republic of China (AQSIQ). Each registered vineyard has a monitoring, prevention and control guide. Only permitted agricultural chemicals are used and the Quarantine bureau of the People's Republic of China (CIQ) is responsible for teaching and monitoring implementation practices.
2. Harvest occurs in the morning after dew or in the afternoon, to avoid the heat.

3. At the packing plant the grapes are inspected visually and with a magnifying glass, and then graded and packaged. Grapes are put in plastic bags, which are then put in fibreboard, plastic or foam boxes. The grapes are pre-cooled and kept cool during transport. The inspection and quarantine organisation in the production area will provide an export receipt of exchange and a certificate of plant inspection.
4. When the commodity arrives at the port, the inspection and quarantine organisation of the port inspects the commodity with the export receipt of exchange and provides the export customs clearance bill to the exporter.
5. The customs department in the port of export inspects the commodity and seals the commodity after receiving the export customs clearance bill.
6. Transport to New Zealand is by air or sea.
7. Each shipment must be accompanied by the appropriate certification, for example a phytosanitary certificate attesting to the identity of the fruit, any treatments completed or other information relating to biosecurity risk mitigation.
8. Fruit is examined at the New Zealand border to ensure compliance with New Zealand's biosecurity requirements.
9. Any fruit not complying with New Zealand's biosecurity requirements (for example found harbouring pest organisms or weed seeds) is either treated, re-shipped or destroyed.
10. Fruit complying with all biosecurity requirements is cleared for entry into New Zealand.
11. Fruit is distributed around New Zealand. Fruit is often stored before being distributed to market for sale. Supermarkets and fruit shops also store fruit before it is bought by consumers.

2.2.2.1 China's regulatory framework for table grape exports

In March 2007, the AQSIQ released administrative procedures for fruit production and processing for export. As of 1 November 2007, all export fruit must be sourced from registered orchards and pack houses (processing facilities). Registration requirements apply to the whole production chain, beginning with harvest, boxes for transferring fruit, grading, anti-rot measures, packing, pre-cooling, storage, and export.

- Specialised boxes must be used for transferring fruit from the orchard to the pack houses to ensure adequate air circulation and security;
- Fresh and processed fruit must be stored separately at the pack houses;
- Cold storage and controlled atmosphere conditions must be monitored continuously to ensure adequate temperature (-1ºC to 0ºC) and humidity are maintained (specialised for fruit type).
- Strict hygiene standards must be applied, including to vehicles etc.;
- A traceability system must be in place for all boxes;

- The company must inspect every consignment. CIQ inspect every consignment prior to export and audit company documentation and inspection records (annually as least but possible more frequently).

CIQ ensures companies have integrated the AQSIQ control requirements into their company control/quality system. If the company fails a CIQ audit then (export) registration is removed. In such instances CIQ would help the company become registered once more. Bags, which are applied two weeks after flowering, are removed before the grapes enter the processing facility. Diseased or damaged fruit are removed during de-bagging with "substandard" fruit sold to the domestic market. The volumes of substandard vs. qualifying fruit are recorded and reported to CIQ. If any pests or anything suspicious was found it would be reported to CIQ, the whole shipment (one vehicle) "quarantined", and the inspection frequency increased.

CIQ train (for 2-3 days as per registration requirements) more than 3 staff, who then become staff trainers. All workers must be qualified and experienced. Each day staff receive a 5 minute lecture to reinforce phytosanitary/food safety controls. It is a requirement of registration that quality system documents are maintained of the daily operations. CIQ update managers on the season's requirements including importing country requirements.

CIQ inspections (prior to export) use visual and magnifying glasses. They also undertake a routine inspection of the whole production system including control systems and documentation. Once a month during processing CIQ undertake a sample inspection of 5% unless an alternative rate/frequency is otherwise stated in the import protocol at a special table outside the processing facility. At this and the pre-export sample inspection (sample rate also dependent on export protocol) CIQ are looking for pests (MAFBNZ, 2008).

2.2.2.2 Pre-harvest operations

The only agricultural chemicals that can be used are those permitted for fruit and vegetables in China. The main pest control measures are depicted in Table 2 (AQSIQ, 2007). A bagging system is used during the growing season and varies according to region and variety. For example, Xinjiang Redglobe grape ears are bagged during the beginning and middle of August. The bags are used to prevent sun-burning and diseases and to keep the grapes clean. The bags are removed during the beginning and middle of September (10 to 15 days before maturity).

Table 2. Main pest control measures used in China for table grapes for export

Period	Objective	Measure
Dormancy	Eliminate plant disease and insects	Clean vineyard, remove dry leaves and stems, burn dry leaves and stems or deeply bury them
After tree buds, before leaves unfold	Powdery mildew, downy mildew, grapevine leaf mite, red mite	1.02 specific gravity of lime sulphur mixture
Before blossom	Downy mildew, botrytis bunch rot and blight	1 : 0.5 : 240-fold dilution of Bordeaux mixture
After blossom falls	Downy mildew, powdery mildew, red mite, white rot	1 : 0.5 : 200-fold dilution of Bordeaux mixture and 800-fold dilution of Carbendazim
Young berries	White rot, powdery mildew, red mite	1 : 1 : 200-fold dilution of Bordeaux mixture
From berry nut hardening to start of grape colouring	White rot, powdery mildew, downy mildew	1 : 1 : 200-fold dilution of Bordeaux mixture
From grape colouring to maturity	White rot, powdery mildew, downy mildew	1 : 1 : 200-fold dilution of Bordeaux mixture
After harvest	Downy mildew, white rot, red mite	800-fold dilution of Carbendazim
After leaves fall	Various pests	Clean leaves and burn them. Clean completely after tree cutting, burn stems and leaves, spray 1.02 specific gravity of lime sulphur mixture and 0.3% soap powder

2.2.2.3 Harvest, processing, packing and transportation procedures

Harvest time depends on the grape variety and factors such as colour, smell, taste, feel, sugar content and acid content. During harvest gloves are worn, and the bunch is cut close to the stem. The white grape powder is wiped off and the grapes are placed in circulation boxes. At the packing plant, unsuitable bunches (small, damaged or having diseased berries) are removed and the grapes are packed according to their grade. The basic requirements for all grape bunches are: a complete and pure bunch without diseases, unusual smell or abnormal internal moisture content, full growth, vigorous and healthy fruit stalk (AQSIQ, 2007). The basic requirements of all grade grapes include: good shape, full growth, suitable maturity, grapes without shatter and peduncle without wrinkle. The harvested grapes are placed in a single layer in a shaded place in the open air for 6 to 8 hours, to allow the superficial moisture and heat from the field to disappear (AQSIQ, 2007). The grapes are airbrushed to remove any contamination. The grapes are inspected visually and with a magnifying glass (MAFBNZ, 2008). The grapes are then packed in individual plastic bags. One plastic bag will contain between 0.5 and 2 kg of grapes. These bags are placed in fibreboard cartons, plastic boxes or foam boxes, which will contain 5 to 10 kg. Grapes are packed in a cooled environment. They are then pre-cooled, with different varieties having different pre-cooling temperatures: for example, -2°C for Redglobe grapes, -1°C for Kyoho grapes and -0.5°C for Munake grapes and non-seed white grapes. The pre-cooling lasts between 12 and 24 hours. After pre-cooling the grapes go into normal cooled storage. Different varieties have different cooled storage temperatures: for example, 0.5°C to 1°C for Redglobe grapes and Kyoho grapes and 0°C to 0.5°C for Munake grapes and non-seed grapes (AQSIQ, 2007). Once a month, during processing CIQ undertakes a sample inspection of 5% unless an alternative rate/frequency is stated in the import protocol (MAFBNZ, 2008). If the grapes have qualified for export, the inspection and quarantine organisation in the production area will provide an export receipt of exchange and a certificate of plant inspection. The grapes are transported in refrigerated trains or trucks from the production area to one of China's major ports for export shipment. When the commodity arrives at the port, the inspection and quarantine organisation in the port will inspect the commodity and provide an export customs clearance bill to the exporter. Next, the customs department in the port will inspect the commodity and after receiving the export customs clearance bill the commodity will be sealed. The commodity can then be exported (AQSIQ, 2007).

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

2.2.2.4 Transport to New Zealand

The commodity can be exported into New Zealand either by air or by sea. In order to identify possible transit times between China and New Zealand, export is assumed to occur from Shanghai, the second largest port in the world in 2007 (UNCTAD, 2008).

Sea Freight: From Shanghai to Auckland takes 22 days (Http://www.tasmanorient.com)

Air freight: From Shanghai to Auckland takes about 12 hours (Http://www.AirNZ.com)

Transport via sea freight is expected to be refrigerated to keep the table grapes in an economically valuable state. Temperatures in the hold of the plane are likely to be average to cold.

2.2.2.5 Distribution and use within New Zealand

From the border, fruit would be transported to the main city centres in New Zealand, first, to either wholesalers or retailers, and then to the food service industry or to individual consumers. Retailers are more likely to be located in urban areas than wholesalers. Although the fruit is imported for consumption, waste will be generated, with wholesalers and retailers potentially disposing of unmarketable fruit, and consumers disposing of waste or uneaten fruit. Table grapes are sold with pedicel and peduncle which would be culled, and often the pips would be discarded too. So some waste material would always be generated from good quality fruit after consumption of berries. 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 taken to a landfill whereas 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. 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

2.3.1 Climate and geography

China covers a land territory of approximately 9.6 million square kilometres and an adjacent sea area of some 4.73 million square kilometres. Although most of the country lies in the temperate belt, its climatic patterns are complex. China's climate is characterised by two distinct types, the continental monsoon climate and the complex climate. Precipitation in China varies markedly between the seasons, with rain falling mostly in summer, and is distributed very unevenly from region to region (see Figure 4). Topographically, China slopes from the west to the east, forming three distinct terraces. Mountainous regions, hilly areas and plateaus comprise 66% of the total territory (National Coordination Committee on Climate Change, 2004).

In terms of climate, China may be divided between the humid eastern region and the dry west. The humid east may be further subdivided between the warm and humid south and south-east and the temperate-to-cool, moderately humid north and north-east. Much of the humid eastern region of China exhibits a monsoonal pattern of temperature and precipitation. In a monsoon climate, the warm summer months are typically the months of maximum precipitation.

A map of China's provinces (Figure 5) is included for ease of reference when geographic locations in China are discussed elsewhere in this document.

Figure 4. Climate zones in China – annual precipitation

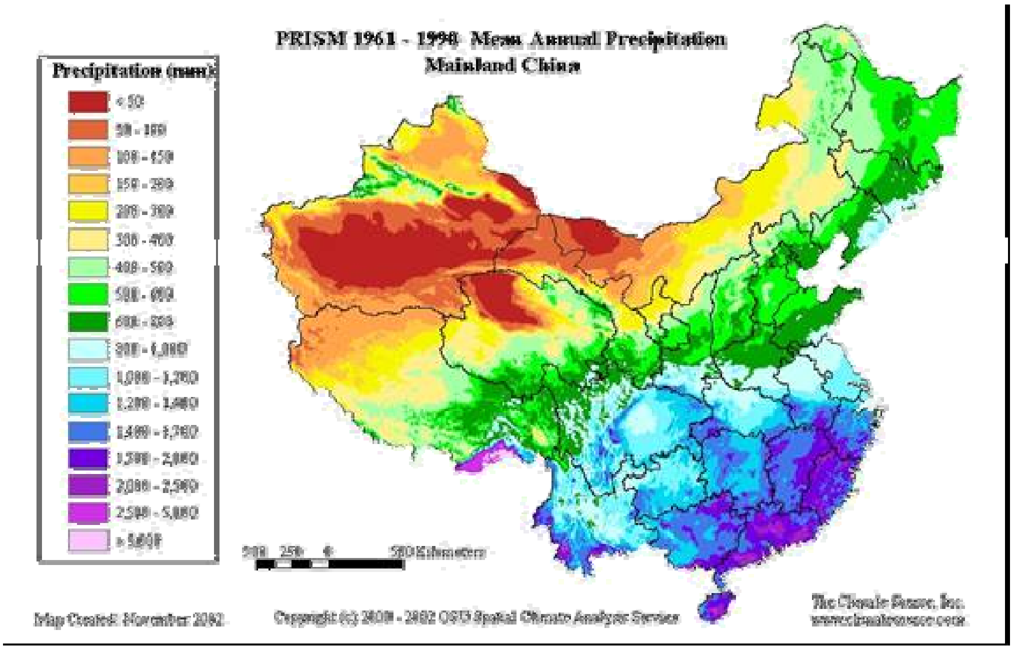


Figure 5. Map of China showing the provinces

2.3.2 Grapevine growing climates

Grapevines can withstand arid climates (less than 200 mm rainfall per year) and low winter temperatures (less than -20°C). The vines develop a deep root system (CPC, 2007). The best soil is sandy loam that is well drained and fairly fertile with a good amount of organic matter (Bose *et al*, 2001). The grapevine is a C3 plant and reaches maximum photosynthesis at high levels of irradiation and around 25°C. Grapevines have a minimal thermal requirement of 18°C (and a temperature vegetation limit of 10°C). In cool climates the grapevine is grown on hilly areas directed towards the sun, in order to increase the local average temperature (CPC, 2007).

2.4 The New Zealand grape industry

2.4.1 Grape production

Grapes in New Zealand are mostly grown for the wine industry. In 2007, only 37 hectares were grown as table grapes, compared to 29 616 hectares for the wine industry (Statistics New Zealand, 2008: accessed 20/11/2008).

New Zealand grapes are largely produced in ten major wine growing regions spanning latitudes 36° to 45° South and extending 1600 km (1000 miles). New Zealand's temperate, maritime climate has a strong influence on the country's predominantly coastal vineyards. The vines are warmed by strong, clear sunlight during the day and cooled at night by sea breezes (NewZealandAtoZ.com, 2008: accessed 20/11/2008). New Zealand's major grape growing areas are, from north to south, Northland, Auckland, Waikato/Bay of Plenty, Gisborne, Hawkes Bay, Wellington, Nelson, Marlborough, Canterbury and Central Otago.

The total amount of grapes produced has increased from around 80 000 tonnes in 1999 to around 300 000 tonnes in 2008 (Table 3) (NZ Wine Growers, 2008). About 60% of the total production is of the variety Sauvignon Blanc. The Marlborough region produced about two-thirds of the total production. The total New Zealand grape production has grown 3.5 times in the last 9 years (Table 3). 3

Table 3. Grape production in New Zealand

GRAPE VARIETY (TONNES)	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Sauvignon Blanc	20,580	15,472	20,826	36,742	28,266	67,773	63,297	96,686	102,426	169,613
Chardonnay	17,823	23,593	17,067	33,883	15,534	35,597	29,741	26,944	38,792	33,346
Riesling	3,462	4,070	4,377	5,038	3,376	5,647	4,792	6,745	6,017	8,547
Pinot Gris	411	572	747	1,214	836	1,888	1,655	3,675	6,053	12,417
Semillon	2,593	2,189	1,887	3,053	2,192	3,511	2,388	2,664	2,929	2,561
Müller Thurgau	8,941	6,353	4,231	4,806	1,685	3,888	2,144	1,573	1,437	847
Gewürztraminer	493	594	460	990	529	1,325	1,164	1,532	2,052	2,101
Muscat Varieties	3,885	3,487	1,694	2,623	1,242	1,828	2,098	1,532	2,017	1,697
Reichensteiner	1,407	1,185	723	1,184	644	1,140	675	762	512	681
Other White Vinifera	1,912	939	801	1,253	330	668	360	344	415	247
Chenin Blanc	2,099	1,992	1,041	1,322	391	1,325	629	337	212	151
Viognier							155	176	543	573
Pinot Noir	4,844	6,319	8,015	10,402	9,402	20,145	14,578	22,062	20,699	32,878
Merlot	3,252	4,090	2,573	6,502	4,957	9,330	9,194	11,206	11,714	10,166
Cabernet Sauvignon	3,723	3,792	2,782	4,375	3,201	4,045	3,018	2,659	2,462	2,270
Malbec	214	363	273	731	458	1,106	763	1,325	1,086	1,036
Syrah	192	257	244	397	330	691	758	1,057	1,514	1,452
Cabernet Franc	618	702	332	827	602	858	782	673	819	688
Pinotage	444	868	487	863	588	917	708	631	890	719
Other Red Vinifera	291	400	375	430	221	400	459	262	227	291
All Hybrids	116	20	51	51	38	17	47	40	8	71
REGION (TONNES)										
Northland	55	105	84	186	182	144	183	208	203	204
Auckland	1,224	1,363	614	1,526	715	1,497	948	1,345	1,241	1,604
Waikato/Bay of Plenty	552	637	411	932	497	457	210	261	212	192
Gisborne	22,133	21,820	12,936	26,587	14,350	25,346	22,493	18,049	26,034	23,911
Hawkes Bay	19,472	23,886	10,887	25,661	10,832	30,429	28,098	33,287	41,963	34,284
Wellington	607	1,124	1,457	2,022	1,311	2,820	1,649	3,008	1,949	4,105
Marlborough	29,229	26,212	36,962	54,496	40,537	92,581	81,034	113,436	120,888	194,639
Nelson	1,383	1,125	2,313	1,785	3,149	4,563	2,454	5,623	5,190	7,002
Canterbury	1,551	788	1,779	1,972	1,422	2,825	895	3,051	1,699	6,881
Otago	1,094	1,009	1,543	1,519	1,825	1,439	1,441	4,612	3,434	9,495
INDUSTRY TOTAL	**79,700**	**80,100**	**71,000**	**118,700**	**76,400**	**165,500**	**142,000**	**185,000**	**205,000**	**285,000**

2.4.2 Imported grapes

Grapes (as fresh produce) can currently only be imported into New Zealand from Australia, USA, Mexico, Chile and Italy, as these are the only countries covered by an existing import health standard.

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, 2008).

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, 2008).

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. Temperatures drop about 0.7°C for every 100 m of altitude (NIWA, 2008).

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 and can be extreme in northern New Zealand and in mountainous areas. Autumn and spring UVI values can also be high in most areas (NIWA, 2008).

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, 2008).

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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 table grapes. The following sources were used:

- pest lists supplied by AQSIQ (AQSIQ, 2007)
- information derived from literature searches, including but not limited to: CAB abstracts (articles published between 1910–2009), Knowledge Management, Plant Health Australia, 2006)
- database searches, including but not limited to: CPC (2007), Farr *et al*. (2008), ScaleNet (2008) (EPPO, 2007)
- internet searches
- a review of organism interception records on previously imported table grapes (MAFBNZ, 2009).

Organisms that may be associated with material that is contaminating the risk goods, if that contaminating material cannot be easily separated from the goods on import, are also considered.

Organisms on the list were screened and were classed as potential hazards if they were likely to be present on the import 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 2. The list, although extensive, is not exhaustive. Whilst it includes most organisms likely to be carried on table grapes there may be information on additional organisms in sources that were not consulted, or which are not accessible.

In the process of identification of hazards associated with table grapes:

- 257 organisms were associated with table grapes;
- 165 were excluded because there was no evidence of their presence in China and/or they were recorded as present in New Zealand;

- of those present in New Zealand, 13 were known pathogen vectors, so were given further consideration;
- all those organisms for which no host association or no association with mature fruit could be demonstrated were excluded;
- the screening process resulted in 35 organisms being considered potential hazards for the commodity and subjected to further assessment (Chapters 5–12).

3.2 Review of organism interception records

Records from the MAF Interception Database (MAFBNZ, 2009) of organisms intercepted at the New Zealand border on imported table grapes, are summarised in Appendix 1. Weed seeds are regularly intercepted on imported grapes. They are not included in Appendix 1 because they are not identified to species level and are outside the scope of this risk analysis.

New Zealand imports table grapes from Australia, Chile, Mexico and USA (California). Samples of imported table grapes are taken for inspection when they arrive in New Zealand. Any organisms found are identified in MAF laboratories and then recorded in the MAF database. 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 (MAFBNZ, 2008). The list has been provided to indicate the types of organisms that are known to be associated with table grapes in international trade.

Since not every organism on a pathway is detected, not every organism is recorded or identified, and search efforts and levels of identification can vary, these data cannot be extrapolated to predict likely pest interception numbers for table grapes from China. In this analysis they have been used only for hazard identification and analysis of likelihood of entry. Viability data, where available, was used in assessing the efficacy of treatments. The risk analysis uses available information to assess risk from organisms associated with table grapes. 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. Interception data is intended to be used as a review tool not as a primary risk mitigation measure.

Interception records are a good means of determining which hitchhiker organisms are likely to be associated with a commodity. Hitchhikers have an opportunistic association with a commodity or item with which they have no biological host relationship, but can be important hazards for other hosts. Literature reviews and country of origin pest lists will not usually identify such organisms as potential hitchhikers on the commodity.

Hitchhikers are common on table grapes, for instance spiders (Araneae) are regularly detected. Several spiders have been identified as hazards on table grapes (MAFBNZ, 2002). Therefore spiders are also likely to be potential hazards on table grapes from China. Other possible hitchhiker organisms on table grapes coming into New Zealand from other countries have been identified and are assessed in Chapter 12. Once trade in table grapes from China starts, the assumptions in this chapter can be verified from the subsequent interception records and risk mitigation measures reviewed if necessary.

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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.

Table grapes 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 (see Section 2.2.1). It is assumed that all table grapes exported from China to New Zealand will follow these standards. They are not considered separately here. Only measures that have a specific, identifiable effect in mitigating risk from particular hazards are discussed.

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. When fresh produce is exported to New Zealand it needs to meet the phytosanitary measures as stated in an IHS, which is independent of the mode of transportation.

4.2 Possible options

4.2.1 Pest-free areas (PFAs)

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.

4.2.2 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.

4.2.3 Bagging of fruit

All table grapes to be exported are generally bagged to reduce the risk of exposure to pests and diseases. All bags adopted are normally double-layered, light and rain proof paper bags. The bagging system is different for different varieties and regions. Taking Xinjiang Redglobe grape as an example, the grapes are bagged during the beginning and middle of August to avoid sun-burning and disease and to keep the grapes clean. The bags are removed during the beginning and middle of September, 10 to 15 days before maturity (AQSIQ, 2007). In other varieties, bags are applied two weeks after flowering and removed only before the grapes enter the processing facility (MAFBNZ, 2008). Bagging will only be a viable risk mitigation option through preventing pests accessing the grapes, if the bags are in place during the whole growing season, right up until harvest of the grapes.

4.2.4 Airbrushing

All table grapes 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. Therefore, airbrushing during the packing process is expected to have some mitigating effect, but is not considered a single viable risk management option.

4.2.5 Cold treatment

The most frequently used temperatures for quarantine treatment of fresh produce is between 0 and 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 able to be 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. Sea transport transit times between China and New Zealand are expected to be approximately 3 weeks. Berries will freeze near -2°C, while the stem will freeze near -1°C (Zoffoli, 2008).

4.2.6 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). Application of dosages up to 900 Gy did not negatively impact the quality of table grapes, with 900 Gy being the maximum dosage tested. Irradiated grapes are residue free and can be packed in less ventilated outer bags (Witbooi and Taylor, 2008).

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).

Biosecurity New Zealand has approved the importation of irradiated tropical fruit from Queensland, Australia. Food Standards Australia New Zealand (FSANZ) has approved and given food safety clearance to the use of irradiation as a phytosanitary treatment for the following imported fruits: mango, rambutan, longan, lychee, papaya, custard apple, breadfruit and carambola. Along with these fruits the only other products available in New

Zealand, and permitted to be irradiated in prescribed doses set out in the Foods Standards Code, are herbs and spices and herbal infusions, excluding tea. Foods are not allowed to be irradiated unless they have been through a pre-market safety assessment process conducted by NZFSA (NZFSA, 2008) (accessed 05/12/2008). Table grapes 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 if the use of irradiation on table grapes is approved by the NZFSA.

4.2.7 Methyl bromide fumigation

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

- Temperature – lower doses can generally be used at higher temperatures due to the increased metabolic activity of the organisms;
- 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. It is also a potent ozone-depleting gas. As a result, methyl bromide is of particular concern in the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The Montreal Protocol aims "to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it, with the ultimate objective of their elimination on the basis of developments in scientific knowledge, taking into account technical and economic considerations and bearing in mind the developmental needs of developing countries". Methyl bromide was recognised as an ozone-depleting substance under the Montreal Protocol and control measures for the chemical were included in the Copenhagen Amendment in 1992. As a signatory, New Zealand is required to phase out the production and consumption of methyl bromide by 1 January 2005. Three categories of methyl bromide use are exempted from phase-out under the control measures – use as a chemical feedstock, uses that the Parties to the Montreal Protocol deem 'critical' and use for quarantine and pre-shipment (UNEP, 2007), but countries are committed to reducing the use of methyl bromide.

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 varietals' 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. Several grape varieties are listed as being tolerant of methyl bromide fumigation (Bond, 1984), but of these only Thompson seedless is widely grown in China. Care should be taken to ensure phytotoxicity levels are acceptable before applying any chemical treatments to plant material. Shelf life may be reduced.

The methyl bromide treatment schedule provided in

Table 4 has been derived from the FAO Manual of Fumigation Control for the treatment of caterpillars, maggots and eggs (if present) of internally feeding Diptera and Lepidoptera, and some scale insects and mites in fresh fruit. The actual level of efficacy of this treatment against all but a few insect species has yet to be determined with any accuracy.

Table 4. Methyl bromide fumigation schedule for surface feeding insect infestations (foliated dormant plants under atmospheric conditions).

Temperature (^{O}C)	Rate (g/m^3)	Duration (hours)	C/T Value ($g\ h/m^3$)
4 to 10	64	3	114
11 to 15	64	2.5	102
16 to 20	64	2	90
21 to 25	48	2	76
26 to 29	40	2	56
30 to 32	32	2.5	48

4.2.8 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 2.2.1.

Formal phytosanitary inspection can occur both pre-export and on arrival in New Zealand, 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 wanted for the absence of a particular organism, how easily the organism can be detected and how homogeneous the distribution of the organism is within the commodity consignment (ISPM No.23, 2005). These factors will be considered in relation to individual hazard organisms in Chapters 5–12. MAFBNZ requires that the NPPO of the exporting country samples and visually inspects the consignment for all regulated pests. This pre-export inspection and certification should comply with the conditions outlined in MAFBNZ Biosecurity New Zealand Standard 152-02: Importation and Clearance of Fresh Fruit and Vegetables into New Zealand.

The AQSIQ procedure states that three consecutive inspection controls will take place, one by the inspection and quarantine organisation in the packing facility, followed by one performed by the inspection and quarantine organisation in the port and finally one performed by the customs department in the port (AQSIQ, 2007). During the first inspection the grapes are airbrushed to remove any contamination and the grapes are inspected with a magnifying glass (MAFBNZ, 2008).

4.2.9 SO_2 fumigation

The main factors that contribute to deterioration of table grapes during storage at low temperatures are decay and water loss. Sulphur dioxide (SO_2) is the accepted standard treatment for controlling gray mould. Gaseous SO_2 is released from the reaction of sodium metabisulfite with the moisture of the environment. Incorporation of a polyethylene box liner ensures the minimum humidity conditions required are achieved (Zoffoli, 2008).

Good ventilation of the fruits in bags is needed to avoid SO_2 damage. The packaging, especially the amount of perforation, has a clear effect on storage and total losses (Dhillon and Sandhu, 1990). The effect varies slightly between grape varieties and is heavily dependent on initial inoculum (Guelfat-Reich and Safran, 1973). Poor control by SO_2 is characterised by the development of nests of decayed berries (Zoffoli, 2008).

In-package slow release sulphur dioxide generating pads can be used during transportation. Some pads release SO_2 at a constant level (G1 pads) and others use a two step release of SO_2 (G2 pads).

Alternatives to SO_2 are being investigated for several reasons. Under the 1958 Food Additives Amendment to the Federal Food, Drug, and Cosmetic Act, any substance intentionally added to food is a food additive and is subject to pre-market approval by FDA unless the use of the substance is generally recognised as safe (GRAS). Ingestion of SO_2 residues (sulphites) can cause hypersensitive reactions in some people. SO_2 was therefore removed from the GRAS list in the USA and reclassified as a pesticide with a residue tolerance. In 1989, the United States Environmental Protection Agency instituted a maximum sulphite tolerance of 10 µg SO_2 per gram in grapes (*Vitis vinifera* L.). Moreover, since it is classified as a pesticide, it cannot be used for certified organic grapes. The treatment can result in unacceptable bleaching injuries and berry taste can sometimes be compromised. Finally workers cannot be exposed to the gas at a level above 2 ppm and some regulatory agencies do not allow discharge to the air after fumigation (Lichter *et al*, 2006).

Although classified as a pesticide, there is little available literature on the effect of SO_2 treatment of table grapes in mitigating the biosecurity risk from arthropods. Observations from the operation of other table grape import pathways indicate that it is also detrimental to mealybugs (S. Gould, MAFBNZ, New Zealand, pers. comm., 5 May 2009). Moreover, it is assumed to have an inhibitory effect on fungi.

4.2.10 Ozone enrichment

The extent of protection against a wide spectrum of micro-organisms afforded by ozone is dependent on the commodity, gas concentration and time of exposure. Ozone is declared safe for food contact applications in the USA. There seems to be a relatively narrow window between lethal threshold to the pathogen and detrimental effects to the berries or browning of the rachis. Moreover, ozone treatment requires special adaptations to storage facilities, due to its corrosive nature (Lichter *et al*, 2006). Therefore ozone is not deemed a currently viable option.

4.2.11 Wet treatments

The current practice of packing grapes with minimal handling makes implementation of wet treatments commercially less attractive. However, the presence of dust and insect frass on the berries, as well as the demand for alternatives for SO_2 and methyl bromide, makes wet processes more acceptable. One of the challenges in wet treatments is a sterile drying period needed before grapes can be placed in storage. Despite these difficulties wet treatments are seen as viable management options.

4.2.11.1 Hot water treatment

When grapes are dried quickly and properly, hot water treatment does not lead to a loss in grape appearance. Moreover, in a study using four grape varieties, one variety 'Thompson Seedless', when treated with water at 40°C or 50°C, showed slightly less browning and shatter than control grapes. Treatments at 55°C and 60°C can lead to damage to rachis and berry appearance (Karabulut *et al*, 2004).

4.2.11.2 Ethanol dip sterilisation

An ethanol dip sterilises the surface of the berries and reduces the subsequent decay of grapes (Lurie *et al*, 2006). An ethanol dip does not leave residual protective action against re-infection and it does not reach the pathogen if it has already germinated and penetrated into the berry. A dip in 50% ethanol for 10 seconds (followed by air drying) did not result in loss of taste of the berries (Lurie *et al*, 2006). An ethanol dip efficiently reduces cell concentrations of spoilage micro-organisms, without affecting respiratory activity of the packaged grapes or their appearance (Del Nobile *et al*, 2008).

Sanitising grapes with ethanol could be done for grapes marketed under organic classification. An additional benefit of ethanol treatment would be the cleaning of the grape berries, for instance removing dust and insect frass. Ethanol has an advantage over other wet treatments because it dries quickly (Lichter *et al*, 2006).

4.2.12 Controlled and modified treatments

The idea behind atmosphere treatments is to provide the product with an atmosphere that differs from normal air so that reactions are changed. Low O_2 and/or high CO_2 have been used to kill certain insects as well as controlling decay-causing pathogens in commodities that can tolerate these conditions (Kitinoja and Kader, 2002; revised 2003). The difference between controlled and modified atmosphere treatments is that in controlled atmosphere there is a continuous control over the atmosphere, while in modified atmosphere treatments there is a change in atmosphere at the beginning of the treatment, but the atmosphere in the packaging changes with time, influenced by the permeation of the packaging material.

Conventional controlled atmosphere against decay causing pathogens is based on the inhibitory effect of CO_2. Browning of stems and rachis as well as effects on flavour are the major issues when using controlled atmosphere (Lichter *et al*, 2006). Regimes vary considerably, varying from several hours to several days (Kitinoja and Kader, 2002, Revised 2003).

Controlled atmosphere is considered a viable option, especially if performed in-transit, which removes the time limitation factor. Modified atmosphere packaging is thought to be a viable alternative to SO_2 if it is combined with another method of protection (Lichter *et al*, 2006).

4.3 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 use of interception data once trade has commenced is one method of monitoring efficacy, as records of live and dead organisms indicate the success of risk management measures and the likelihood of potential hazards surviving the import process. However, interception records can rarely be used quantitatively because of limitations in the identification and recording processes.

The risk analysis uses available information to assess risk and clearly sets out the major remaining uncertainties and assumptions in the risk assessment for each potential hazard. Review of interception records is a good way testing these assumptions. They are intended to be used as a review tool not as a primary risk mitigation measure nor a tool to prove efficacy of a suggested measure. Measures are only suggested to be viable if there is clear evidence for their efficacy, and this is not dependent on interception data once trade from China has began.

4.4 Assessment of residual risk

Residual risk can be described as the risk remaining after measures have been implemented. Assumptions are:

- the measures have been implemented in a manner that ensures they reduce the level of risk posed by the hazard(s) to a degree anticipated by the risk analysis; and
- the level of risk posed by the hazard(s) was determined accurately in the risk assessment.

The remaining risk, while being acceptable, may still result in what could be interpreted as failures in risk management. There is a range of risk management measures, or combinations of measures, that will reduce the risk associated with this pathway by varying amounts. Whatever options are chosen it is advisable to monitor whether the residual risk is within the expected acceptable level. Residual risk information in this case would be interception data from the table grape consignments coming into New Zealand from China.

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5 Analysis of potential hazards – Coleoptera (beetles)

5.1 Coccinellidae – ladybird beetles

The following Coccinellidae species are grouped together, because the biosecurity risk they present is likely to be similar.

Scientific name: *Harmonia axyridis* (Pallas, 1773) (Coleoptera: Coccinellidae)
Other relevant scientific names: *Coccinella 19-sinata* Faldermann; *Coccinella axyridis* Pallas; *Coccinella conspicua* Faldermann; *Ptychanatis axyridis* (Pallas)
Common names: harlequin ladybird, multicoloured Asian ladybird

Scientific name: *Coccinella transversalis* Fabricius (Coleoptera: Coccinellidae)
Other relevant scientific names: *Coccinella repanda transversalis* Thunberg; *Coccinella repanda* Thunberg
Common name: transverse ladybird

5.1.1 Hazard identification

5.1.1.1 New Zealand status

Harmonia axyridis and *Coccinella transversalis* are not known to be present in New Zealand. Not recorded in: Spiller and Wise (1982); Scott and Emberson (1999). Recorded as not established in New Zealand in PPIN (2009: accessed 16/02/2009).

The record of *C. transversalis* in New Zealand published in the 2001 edition of the Compendium was found to be erroneous and has been removed from the distribution list (CPC, 2007: accessed 16/02/2009).

5.1.1.2 Biology

Harmonia axyridis:

H. axyridis is a large predatory coccinellid beetle native to the eastern Asian region. It has been released in North America and Europe as a classical biological control agent among others against several citrus pests.

It is considered bivoltine in much of Asia, although in favourable conditions it can be multivoltine and up to four or five generations per year have been observed (biology is according to a review by Koch (2003), unless stated otherwise). The life cycle proceeds through an egg, four larval instars, a pupa and adult stages. At 26°C on a diet of *Acyrthosiphon pisum* the mean duration of the stages is as follows: egg 2.8 days, first instar 2.5 days, second instar 1.5 days, third instar 1.8 days, fourth instar 4.4 days and pupa 4.5 days. Development from egg to adult takes 267.3 degree days above a lower developmental threshold of 11.2°C in the USA and 231.3 degree days above 10.5°C in France. Adults typically live 30 to 90 days depending on temperature, although they may live up to three years.

Larvae range in size from 1.9 to 2.1 mm in the first instar to 7.5 to 10.7 mm in the fourth instar. The total number of aphids consumed through the larval stages can vary from 90 to 370 aphids, depending on the species of aphid. The mean daily aphid consumption by adults ranges from 15 to 64 aphids a day. Adults are 4.9–8.2 mm in length and 4–6.6 mm in width. The coloration and maculation is highly variable.

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 oval shaped and about 1.2 mm long, and are laid in irregular masses that are usually found on the lower surface of leaves infested with aphids (Tan, 1933). 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 migrates to overwintering sites where the adults spend winter in a state of dormancy in large aggregations. In Japan, it acclimates to winter by decreasing its supercooling point and lower lethal temperature to approximately -19° and -16°C, respectively. Most of winter is passed in a state of diapause. In late winter or early spring, adults switch to a quiescent state and upon arrival of warm temperatures they mate and disperse.

Cannibalism appears to play an important role in the population dynamics, with up to 50 percent cannibalism on eggs being reported. *H. axyridis* displays kin recognition and is less likely to cannibalise a sibling than a non-sibling. *H. axyridis* can be conditioned, for example to associate one colour with food.

Coccinella transversalis:

Feeding preferences, longevity and reproductive potential of *C. transversalis* show significant correlation with the aphid prey quality. Predatory efficiency is directly proportional to pray density (Babu and Ananthakrishnan, 1993).

In a laboratory study in South India (conditions not given), *C. transversalis* took 3 days to hatch. With *Myzus nicotianae* as prey, the four larval instars took 1.9, 1.5, 1.5 and 2.9 days respectively and the total larval period was 7.75 days. The pre-pupal period averaged 0.5 days and the pupal period was 3.1 days. The average longevity of the adults was 32.7 days, leading to a complete life cycle taking 46.75 days (Jagadish and Jayaramaiah, 2005). In a laboratory study in the Philippines (conditions not given), in which *C. transversalis* was reared on *Aphis craccivora*, the eggs had an incubation period of 3.8 days, the pupal period lasted 3.8 days and the total development period from egg to adult emergence took 13–15 days. The adults lived for an average of 51.3 days (Balbarino and Ceniza, 2005). It should be noted that differences in life cycle times can be caused by a combination of various factors such as temperature, geographic strain, or prey species.

In a laboratory study in the Philippines, egg laying usually started two to three days after mating, or approximately 8 to 10 days after adult emergence. The female laid an average of 1000 eggs, 17 to 40 daily. Unmated females rarely oviposited eggs and these eggs were unfertile (Balbarino and Ceniza, 2005). In a laboratory study in India, eggs measured about 1mm in length and were laid mostly clustered on the underside of the leaf. Each cluster contained 20 to 25 eggs (Debaraj and Singh, 1990). First instar larvae measured 2.5 mm, while second instars were 3.4 mm long. Third instars measured 5.7 mm long, while fourth instars were 9.5 mm long. The pupae measured 5.4 mm and the adults measured 5.9 mm long on average (Debaraj and Singh, 1990). In the Philippines study, the adults of both sexes lived for between 38 and 62 days, with an average of 51 days (Balbarino and Ceniza, 2005). In the study in India, a single larva consumed 401 to 736 *Aphis craccivora* aphids during its development (Debaraj and Singh, 1990). In a different study in India, the larvae consumed an average of 227 *Hysteroneura setariae* aphids, while the adults consumed an average of 2094 aphids (Jagadish *et al*, 1996). In a study to determine the effect of temperature regime on life history parameters, females lived longer and produced more eggs at 30°C than at 20°C (Veeravel and Baskaran, 1996). Prey consumption by the larvae as well as adults was found to be maximum at 29°C, with no feeding seen at 40°C.

5.1.1.3 Hosts

Coccinellid predators are known to attack almost all species of aphids (Jagadish *et al*, 1996). In addition, predatory coccinellids will feed on other organisms in the Tetranychidae, Psyllidae, Coccoidea, Curculionidae and Lepidoptera families. However, individual species usually have strong preferences for particular types of prey. Since their prey may be found on fruit or in the vicinity of fruit, coccinellids may also occur on fruit.

H. axyridis is a generalist predator of insects such as aphids (for example, the green peach aphid *Myzus persicae* (Wang and Shen, 2007)), and scales. Other insect groups have been recorded as prey including immature stages of coccinellids (CPC, 2007). *H. axyridis* also feeds on pollen and nectar (Koch, 2003). 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; Ratcliffe, 2002). *H. axyridis* has been intercepted alive on *Pyrus bretschneideri* (Ya pears) from China in 2004.

C. transversalis is known primarily as a predator of aphids, but will prey on other soft-bodied insects including psyllids (Mensah and Madden, 1993) and noctuid larvae (Evans, 2000). *C. transversalis* has been intercepted five times on grapes from Australia (MAFBNZ, 2009).

5.1.1.4 Plant parts affected

Fruit (CPC, 2007).

5.1.1.5 Geographic 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, the USA and South America, enhancing its worldwide dispersal (CPC, 2007; Koch, 2003). It has been reported from Africa, Asia (China, among others), Europe, North America and South America (CPC, 2007; Koch, 2003).

C. transversalis has been recorded from Asia (among others, China), USA, Central America and Oceania (Australia and Tonga) (CPC, 2007; Debaraj and Singh, 1990; Patro and Sontakke, 1994). The record of *C. transversalis* in New Zealand published in the 2001 edition of the Compendium was found to be erroneous and has been removed from the distribution list (CPC, 2007).

5.1.1.6 Hazard identification conclusion

H. axyridis has been recorded on grape vine, and is associated with the fruit. It is present in China and is not known to be present in New Zealand. Therefore, *Harmonia axyridis* is considered to be a potential hazard.

C. transversalis has been recorded on grape vine, and is associated with the fruit. It is present in China and is not known to be present in New Zealand. Therefore, *Coccinella transversalis* is considered to be a potential hazard.

H. axyridis is recorded as feeding on grapes as well as aphids and is therefore used as a representative for both ladybird beetles in the further assessment.

5.1.2 Risk assessment

5.1.2.1 Entry assessment

The ladybird is predominantly a predator of other insect species and is not usually directly associated with the fruit. The adults are sometimes associated with soft fruit in the absence of prey in the autumn (CPC, 2007). Larvae and adults tend to show an aggregated distribution. While adults are highly mobile, and thus might be expected to fly away during picking, they are reportedly hard to remove from clusters of grapes during harvest (CPC, 2007; Koch, 2003). 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:

- *H. axyridis* is assumed to be widespread in orchards in China;
- adults are the life stage likely to be associated with harvested fruit;
- clusters of adults and their damage to grapes can be visible to the eye;
- adults are reportedly difficult to remove from clusters of grapes during harvest;
- adults have been intercepted on imported fruits from China;

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

5.1.2.2 Exposure assessment

H. axyridis appears to have a high ability to track aphid populations in space and time (Koch, 2003). *H. axyridis* is a highly mobile species. The adult flies readily between host plants, seeking high-density aphid populations. They would be able to move off any infested fruit disposed of in the environment in New Zealand. Predators are more likely to move away from grape bunches in search for prey. *H. axyridis* is a generalist predator feeding on widely distributed insects such as *Myzus persicae* (Wang and Shen, 2007), 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;
- *H. axyridis* is a generalist predator and there would be no shortage of suitable prey available;

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

5.1.2.3 Establishment assessment

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

H. axyridis is primarily a polyphagous species that inhabits orchards, forest stands and old-field vegetation. It thrives and breeds in agricultural habitats, such as forage crops, maize, soybean 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). It is unlikely that climatic factors will prevent the establishment of *H. axyridis* in New Zealand.

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). *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:

- *H. axyridis* is sexually reproducing therefore a mated female or at least one individual of each sex would be required to start a reproducing population;
- initial deliberate introductions into the US for biological control failed to establish;
- suitable prey are common and widely available;
- *H. axyridis* has rapid dispersal ability;
- *H. axyridis* can exploit a wide diversity of habitats;
- New Zealand's climate is highly suitable for *H. axyridis*;

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

5.1.2.4 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, when invertebrate prey become scarce in autumn, it is also reported feeding on orchard and vineyard 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)).

Given that:

- *H. axyridis* is a classical biological control agent that preys on a variety of soft-bodied invertebrate pests including aphids in orchards and crops, which can result in reductions in both pests and pesticide usage;
- *H. axyridis* can damage fruits in orchards and vineyards;
- *H. axyridis* can taint grapes during crop processing;

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 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).

Given that:

- *H. axyridis* is a polyphagous predator of native and introduced species;
- *H. axyridis* appears to be a top predator;
- *H. axyridis* is capable of invading many different habitats;
- *H. axyridis*, therefore, poses a risk to native biodiversity;

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

Human health consequences

During the autumn migrations they form mass aggregations and like to land on white or light-coloured objects, like buildings. Aggregation sites are often homes and *H. axyridis* 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) (accessed 10/02/2009). *H. axyridis* has also been reported to bite humans and some people have developed an allergic rhinoconjunctivitis (Goetz, 2008). *H. axyridis* sometimes overwinters in beehives, where it is a nuisance to the beekeepers, but not harmful to the bees (Koch, 2003). They also may swarm and land on people (Weeden *et al*, 1996).

Given that:

- *H. axyridis* can aggregate in large numbers on and inside buildings during autumn and winter;
- some people have reported experiencing bites from *H. axyridis*;
- some people have reported allergic reactions to *H. axyridis*;

The potential human health consequences are considered low.

5.1.2.5 Risk estimation

The likelihood of entry is considered to be moderate, the likelihood of exposure is considered to be moderate, and the likelihood of establishment is considered to be moderate. The potential economic consequences of establishment are considered to be positive to a low level, the potential environmental consequences of establishment are negative to a moderate level, and the potential human health consequences of establishment are considered to be low. *As a result the risk estimate for* Harmonia axyridis *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified. Taking into account the representative risk assessment for* H. axyridis*, the risk for* Coccinella transversalis *is considered to be non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

5.1.2.6 Assessment of uncertainty

There is little information on the biology of *Coccinella transversalis.* It is assumed that it is sufficiently similar to that of *Harmonia axyridis* for the risk estimation to be the same. By taking this approach the level of risk may be overestimated for *C. transversalis*. Nevertheless the outcome is still estimated as non-negligible for each of the sections and therefore non-negligible for overall risk. In addition, *C. transversalis* has been intercepted at the border on grapes from Australia so is capable of associating with this commodity.

There is uncertainty and considerable debate over the ecosystem effects of generalist predators, as well as uncertainty around how frequently this insect is associated with fruit. There is still uncertainty on the level of adverse effects on humans and crops.

5.1.3 Risk management

5.1.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. *H. axyridis* is native to China, widespread and often used as a biological control agent. Pest-free areas can be a viable option if pest freedom is verified, but this is currently not considered a viable option.

Bagging of fruit

Harmonia axyridis are relatively large. The practice of bagging individual fruit is likely to prevent adults from accessing the fruit surface. However, bagging will only be a viable risk mitigation option if the bags are in place during the whole growing season, right up until harvest of the grapes. If bagging occurs until harvest it is considered a viable option together with pre-export phytosanitary visual inspection.

Pre-export phytosanitary visual inspection

Eggs are laid on leaves and are not associated with the fruit. Adults may be associated with fruit, but are relatively large 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). Pre-export phytosanitary visual inspection is likely to detect *H. axyridis,* although sample inspection may miss infested lots. Pre-export phytosanitary visual inspection is considered a viable option when combined with bagging.

Cold treatment

H. axyridis is tolerant of temperatures below freezing. Depending on the time of year, *H. axyridis* has a survival time varying between 30 and 200 days at -5°C. Moreover, at 0°C this time averages 340 to 380 days. The optimum temperature for overwintering was determined as being between -5°C and 0°C (Watanabe, 2002). After 6 weeks at -10°C, 10% still survived while after 18 weeks at -5°C, 66.5% were still alive ((Berthiaume *et al*, 2003). Therefore, cold treatment at temperatures that will not damage the commodity is not considered to be an effective single risk management measure.

Methyl bromide fumigation

The plant protection and quarantine department of the USDA currently recommends one of following methyl bromide treatments against external feeders on grapes from Chile (TQAU USDA, 2008)

Table 5. Treatment T101-i-2-1

Temperature (ºC)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
26.67ºC or above	24	19	14
21.11 to 26.11ºC	32	26	19
15.56 to 20.56ºC	40	32	24
10.00 to 15.00ºC	48	38	29
4.44 to 9.44ºC	64	48	38

The treatment duration has been changed to 3 hours (as of 24 Jan 2006). The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, treatment must kill 99.9968% of the pests in a test of at least 100 000 individual pests. This treatment schedule is described as being suitable for tarpaulin or chamber fumigations, however no treatment efficacy level is provided. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *H. axyridis* or if evidence is provided of the efficacy against *H. axyridis* on table grapes, then methyl bromide fumigation is considered a viable option.

References for Chapter 5

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6 Risk assessment of potential hazards – Diptera (flies)

6.1 *Bactrocera dorsalis* – oriental fruit fly

Scientific name: *Bactrocera dorsalis* (Hendel, 1912) (Diptera: Tephritidae)
Other relevant scientific names: *Bactrocera conformis* Doleschall; *Dacus dorsalis* Hendel
Common names: oriental fruit fly, mango fruit fly

6.1.1 Hazard identification

6.1.1.1 Taxonomy

Oriental fruit fly, *Bactrocera dorsalis* (*sensu stricto*) is part of a species complex (the *B*. (*B*.) *dorsalis* complex) within the subgenus *Bactrocera*. 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.

6.1.1.2 New Zealand status

Bactrocera dorsalis is not known to be present in New Zealand. Not recorded in: Charles (1998), PPIN (2009: accessed 02/02/2009), Scott and Emberson (1999), Macfarlane and others (2000).

6.1.1.3 Biology

Reproduction is biparental with a lek mating system (a lek is a place where males display in groups and females choose) (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. In laboratory studies conducted in Bangladesh it was found that larval diets without protein sources significantly lowered the weight of resulting pupae (Mahfuza *et al*, 1999).

The duration of each life stage is dependent on environmental factors, with estimates for egg, larval, pupal and male and female adult longevity between 3.3–6.8, 8.3–92, 6.1–41, 51 days and 73–123 respectively and total life span ranging from 48.4–123 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).

In studies conducted in China on the influence of temperature on the development of *B. dorsalis* it was found that the development of pre-adults ranged from 30.4 days at 19°C to 17.4 days at 36°C. Of the temperatures tested, 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).

In the south western region of Kunming (Yunnan, China) field observations of the fly on the high plateau 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, 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, re-establishing onto Lambay Island 12 km off the south-west coast of Taiwan after an eradication attempt there. The main reason for re-infestation was the transportation of infested fruit between the two localities, but several marked males were recaptured on Lambay Island, indicating the tephritid can migrate long distances (Chu and Chiu, 1989). In studies on foraging behaviour *B. dorsalis* was recorded moving up to 600 m between areas of food and non-food plants in the field in Taiwan (Chiu, 1983).

6.1.1.4 Hosts

Bactrocera dorsalis attacks over 300 cultivated and wild fruit (Mau and Matin, 1992). Almost any soft fruit with a skin thin or soft enough to permit penetration is a potential host of a member of the *B. dorsalis* species complex (CPC, 2007). It attacks (among many others): grape (Chu and Tung, 1996; Ren *et al*, 2008), *Aegle marmelos* (golden apple), *Capsicum annuum* (bell pepper), *Citrus* spp., *Feijoa sellowiana* (Horn of plenty), *Cucumis melo* (melon), *Cucumis sativus* (cucumber), *Lycopersicon esculentum* (tomato), *Malus domestica* (apple), *Mangifera indica* (mango), *Passiflora edulis* (passionfruit), *Persea americana* (avocado), *Prunus* spp., *Psidium guajava* (guava), *Solanum torvum* (turkey berry), *Syzygium samarangense* (water apple) (CPC, 2007).

6.1.1.5 Plant parts affected

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

6.1.1.6 Geographic distribution

Bactrocera dorsalis is widespread throughout much of Pakistan, India, Sri Lanka, Myanmar, Indonesia, Malaysia, Thailand, Cambodia, Laos, Vietnam, southern Japan, China, Taiwan, Philippine Islands, Micronesia, and in the USA it is currently present on all major Hawaiian Islands (Weems and Heppner, 1999).

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, 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.

6.1.1.7 Hazard identification conclusion

B. dorsalis has been recorded on grapevine and is associated with its fruit. It is present in China, and is not known to be present in New Zealand. Therefore, *B. dorsalis* is considered a potential hazard.

6.1.2 Risk assessment

6.1.2.1 Entry assessment

The life cycle of the fly indicates that larval life stages will be in the fruits at the time of harvest. The eggs can hatch in a day given optimal conditions and the larvae burrow into the fruit to feed for 8 to 92 days. Therefore, eggs laid in a grape berry just prior to harvest and larvae, which feed inside fruit, would be expected to survive export to New Zealand. Pupation occurs in soil so pupae are not likely to be present on the pathway. Adults are highly mobile, easily disturbed and require a protein source to reproduce and would not be expected to remain with fruit after harvest. Dead *Bactrocera* species have been intercepted on grapes from Italy (Weems and Heppner, 1999).

The likelihood of entry will depend on the prevalence of *B. dorsalis* in areas in which the exported grapes are grown. *B. dorsalis* has not been recorded from many provinces in China because winter temperatures are too cold in some provinces (for example, Xinjiang, Gansu, Shaanxi, Henan, Anhui, Shandong, Hebei, Shanxi, Liaoning and Jilin). However, it may be introduced to these regions through human assisted movement of infested produce from more southerly regions where it is present. For example, *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:

- *B. dorsalis* has not been recorded in all provinces in China so may not occur in at least some of the areas in which grapes for export are produced;
- pupae are not associated with fruit;
- adults are unlikely to remain with fruit during the harvest and packing process;
- eggs and larvae are likely to be associated with fruit at harvest;
- eggs and larvae occur inside the fruit and are unlikely to be detected at harvest;
- a proportion of larvae are expected to survive shipping to New Zealand;

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

6.1.2.2 Exposure assessment

Eggs or larvae entering the country will have to mature to adulthood. Infested fruit must remain in a suitable condition long enough for larvae to develop to maturity. Larvae would then need to find a suitable pupation site – this is usually soil. The likelihood of finding a pupation site depends on the method of fruit disposal. In New Zealand, damaged and uneaten grapes are frequently disposed of in compost heaps which would provide ideal conditions for development through to the pupal stage which could then access soil for development through to adulthood.

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, as well as grape. There would be no shortage of host plants available for most of the year.

Given that:

- larvae in infested fruit would need to find suitable pupation sites;
- compost heaps would provide appropriate conditions for development to pupation;
- host plants occur widely, both in commercial and domestic situations;

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

6.1.2.3 Establishment assessment

Adults need to locate an adult of the opposite sex to be able to reproduce. 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. Adult longevity and the lek mating system are likely to enhance the likelihood of adult flies finding a mate.

Parts of New Zealand where mean temperature does 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; Stephens *et al*, 2007). The adults are best able to survive low temperatures, with a normal torpor threshold of 7°C, dropping as low as 2°C in winter (Smith, 1997).

Although *B. dorsalis* is polyphagous and there would be no shortage of host plants available for most of the year, the presence of fruit for oviposition may be a limiting factor for the establishment of *B. dorsalis* entering New Zealand in fruit in early spring.

As a result of global warming the climatic suitability of regions in New Zealand could increase substantially (Stephens *et al*, 2007). Once established in the northern part of the country, re-establishment to 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 increase the chance of finding a mate;
- CLIMEX modelling indicates that persistent populations could establish in parts of New Zealand;

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

6.1.2.4 Consequence assessment

Economic consequences

Detection of *B. dorsalis* in New Zealand's fruit fly surveillance programme would need to be reported internationally and would 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.

Adults disperse easily, being strong fliers, and lay eggs in the soft skin of ripening fruit. On hatching, the maggots bore further into the fruit and feed on soft pulp. The affected fruit become malformed and, in conjunction with bacterial activity, rot and ultimately fall from the plant (Duyck *et al*, 2004). The reduction in harvest for infested crops would be significant.

As an example of the cost of establishment of fruit flies to the economy, it has been estimated that if any of the four fruit fly species (Mediterranean, melon, oriental, and Malaysian) became established in California, it could cost over $1.4 billion a year in lost markets, export sanctions, treatment costs, and reduced crop yields (Tara *et al*, 2006). There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- there would be significant reduction in yield in many crops;
- treatment costs would be increased for many crops;

- there would be reduced market access overseas for many of New Zealand's export crops;

The potential economic consequences are considered to be high and therefore non-negligible.

Environmental consequences

B. dorsalis has been recorded attacking at least six *Syzygium* species in other countries (CPC, 2007; Ranganath 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 this tree species predominantly occurs. The *B. dorsalis* complex has been recorded from *Solanum* spp. Even though this is a large genus, Beever and others (2007) identified the complex as a potential threat to poroporo (*S. aviculare* and *S. laciniatum*). The likelihood of the fruit fly contacting and establishing on native hosts is less than the likelihood of it infesting fruit and vegetable crops, or orchards. In addition, there is potential for adverse effects on native Tephritidae fauna because in all cases where *B. dorsalis* has invaded, the existing polyphagous fruit fly species have been displaced (Duyck *et al*, 2004; Stephens *et al*, 2007). However, it appears that all New Zealand tephritids belong to a different sub-family (Tephritini) from fruit feeding tephritids such as *B. dorsalis* which is in the subfamily Dacinae (Macfarlane *et al*, 2000; Norrbom, 2004). Flies in the subfamily Tephritini feed on seeds of Asteraceae (Norrbom, 2004) and therefore would not be in direct competition with *B. dorsalis* for food resources.

Given that:

- *B. dorsalis* could attack and be damaging to some native plant species;
- *B. dorsalis* is more likely to infest fruit and vegetable crops, or orchards;

The potential environmental consequences are considered to be low and therefore non-negligible.

Human health consequences

B. dorsalis from human stools has been recorded as one of the main causative agents of pseudomyiasis in Pakistan (Khan and Kahn, 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 conditions include farm or domesticated animals in close proximity to human living areas and low levels of hygiene.

Given that:

- there is a theoretical but unproven risk of *B. dorsalis* being one of the main causative agents of pseudomyiasis in Pakistan;
- conditions required to facilitate this are unlikely to occur in New Zealand;

The potential human health consequences are considered to be negligible.

6.1.2.5 Risk estimation

The likelihood of entry is considered to be moderate, the likelihood of exposure is considered to be moderate and the likelihood of establishment is considered to be moderate. The potential economic consequences are considered to be high, the potential environmental consequences are considered to be low, and the potential human health consequences are considered to be negligible. *As a result the risk estimate for* Bactrocera dorsalis *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

6.1.2.6 Assessment of uncertainty

Oriental fruit fly, *Bactrocera dorsalis* is part of a species complex within the subgenus *Bactrocera*, and it is likely that some information on the species is unreliable due to taxonomic confusion and misidentifications.

The geographic distribution of the main exporting vineyards is not known. The likelihood of entry depends on the distribution of *B. dorsalis* in relation to the exporting vineyards.

6.1.3 Risk management

6.1.3.1 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 freedom

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). In regard to fruit fly there is an extra standard that provides guidelines for the establishment of pest free areas for fruit flies (Tephritidae) of economic importance, and for the maintenance of their pest free status, namely ISPM 26 (IPPC, 2007). Pest freedom status is achieved via a systems approach and fruit fly trapping to monitor population levels in and around orchards. *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 south 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). Since *B. dorsalis* has not been reported from northern provinces of China, pest free area status may be an option for table grapes exported from certain provinces. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *B. dorsalis*.

Cold treatment

Fruit is often subjected to a mandatory cold-sterilisation period to kill off internal feeders. For example, the USA requires cold treatments against fruit flies and moths which can vary from 14 to 22 days depending on the temperature, with a maximum of 2.2°C (IPPC, 2007). Citrus fruit in Australia is normally cold treated for fruit flies at 1°C. This gives full protection, but does leave some damage to the fruit. Citrus fruit treated for 20 days at 3°C or 18 days at 2°C gave a total disinfestation against the Mediterranean fruit fly as well as the Queensland fruit fly (AFFA, 2006). The most cold-tolerant life stage for *Bactrocera tryoni* is the first instar. Treatment of more than 100 000 first instars of *B. tryoni* for 12 days at 1°C on blueberries resulted in no survivors (Jessup *et al*, 1998). Table grapes can be successfully disinfested from the Queensland fruit fly in 12 days at 1°C and the Mediterranean fruit fly in 16 days at 1°C (HAL, 2008). No efficacy data was mentioned.

The USDA states a cold treatment against *B. dorsalis* in lychee, logan, carambola and sand pear of 17 days at 0.99°C or below or 20 days at 1.38°C or below (TQAU USDA, 2008). A test of 34 490 *B. dorsalis* larvae on mangosteen resulted in no survivors after 13 days at 6°C (Burikam *et al*, 1992). 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 grape bunches which have a different fruit texture. Even though cold treatment is effective on other commodities, no large-scale commercial tests have been performed to show the efficacy of cold-treatment of table grapes against *B. dorsalis*. If the efficacy of this treatment as stated for other commodities is accepted as being effective against *B. dorsalis* on table grapes or if evidence is provided of the efficacy against *B. dorsalis* on table grapes, then cold treatment is considered a viable option.

Offshore Methyl bromide fumigation followed by cold treatment

For table grapes coming into the USA, a methyl bromide fumigation followed by cold treatment is currently used as a treatment against *B. dorsalis* (HAL, 2008). The fumigation times and cold treatment times can vary. There are currently three treatment schedules with different combinations of fumigation and cold treatments accepted by USDA-PPQS (TQAU USDA, 2008):

Table 6. Treatment T108-a-1

Temperature (ºC)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
21.11 ºC or above	32	25	18
Followed by a cold treatment			
Temperature (ºC)	Exposure period		
0.56 to 2.77ºC	4 days		
OR 3.33 to 8.33ºC	11 days		

Table 7. Treatment T108-a-2

Temperature (ºC)	Rate (g/m3)	Minimum concentration readings (g/m3) at:		
		0.5 hr	2 hrs	2.5 hrs
21.11 ºC or above	32	25	18	18
Followed by a cold treatment				
Temperature (ºC)		Exposure period		
1.11 to 4.44ºC		4 days		
OR 5 to 8.33ºC		6 days		
OR 8.88 to 13.33ºC		10 days		

Table 8. Treatment T108-a-3

Temperature (ºC)	Rate (g/m3)	Minimum concentration readings (g/m3) at:			
		0.5 hr	2 hrs	2.5 hrs	3 hrs
21.11 ºC or above	32	25	18	18	17
Followed by a cold treatment					
Temperature (ºC)		Exposure period			
6.11 to 8.33ºC		3 days			
OR 8.88 to 13.33ºC		6 days			

The United States has required that the efficacy of commodity treatments for certain pests, especially fruit flies, meets or exceeds a Probit 9 statistical standard. To meet this standard, treatment must kill 99.9968 percent of the pests in a test of at least 100 000 individual pests. This treatment schedule is described as being suitable for tarpaulin or chamber fumigations however no treatment efficacy level is provided. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *B. dorsalis* on table grapes or if evidence is provided of the efficacy against *B. dorsalis* on table grapes, then methyl bromide fumigation followed by cold treatment is considered a viable option.

Pre-export phytosanitary visual inspection

Pre-export phytosanitary visual inspection of the consignment for oviposition punctures should reveal old puncture sites but it may be difficult to detect a new puncture in very recently infested fruit. The efficacy of detecting fruit fly infested fruit can be lower than for some other insects. Emerging larvae or adults on the fruit surface may be detected on arrival in New Zealand. Pre-export phytosanitary visual inspection will assist in reducing the likelihood of entry but is not considered to be sufficient as a single viable phytosanitary measure.

6.2 *Drosophila suzukii* - spotted wing drosophila

Scientific name: *Drosophila suzukii* (Matsumura) [Diptera / Drosophilidae]
Other relevant scientific names: *Leucophenga suzukii*
Common name/s: spotted wing Drosophila, cherry vinegar fly

D. suzukii is part of the *suzukii*-subgroup, which is part of the *Drosophila melanogaster* species-group (Bock 1980). It is easily confused with other species. *D. melanogaster* is known as the common fruit fly. Flies belonging to the family Tephritidae are also called fruit flies, which can lead to confusion, especially with the latter family known to be economic pests in fruit production. Strictly, species in the Drosophilidae should be known as vinegar flies, rather than fruit flies.

Limited information is known about *D. suzukii,* and where needed the assumption is made that the biology is similar to that of other species in the *D. melanogaster* species-group.

6.2.1 Hazard identification

6.2.1.1 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).

6.2.1.2 Biology

D. suzukii is one of only two of the 3000 species of *Drosophila* that is a plant pest (USU, 2009). *D. suzukii* is widely distributed in Japan, where it infests among others cherries and grapes severely (Kanzawa 1939). The percentage of cherry fruits infested ranges up to 75%. (Kanzawa, 1936). *D. suzukii* thrives at cooler temperatures. Wounds are open to fungal, 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 (ODA, 2009), females do not have these wing spots (Dreves *et al*., 2009). Females can only be identified by a trained entomologist (ODA, 2009). Males have two darkened bands on the forelegs (Dreves *et al*., 2009). The larvae of most *Drosophila* spp. remain undescribed (CPC, 2007: *D. Melanogaster*), so it is not possible to present a comprehensive diagnosis. The male body is 0.7-0.94 mm in width, while the female body is 0.85-1.24mm (Kawase & Uchino, 2005). The flies are 2-3mm in body length size (Dreves *et al*., 2009). Pupae are 2-3 mm in length (Dreves *et al*., 2009). The adults are temperature sensitive. They remain motionless at 5 degrees C., begin to crawl at 10 degrees C., are most active about 20 degrees C. and show less activity at 30 degrees C (Kanzawa, 1939).
In Japan, there appear to be about 15 generations a year, the shortest life-cycle lasting 8 days. (Kanzawa, 1939). In the warm California climate 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 degrees C and about 9-11 at 25 degrees C (Kanzawa 1939). The females begin to oviposit 1-4 days after emergence (Kanzawa 1939) The female penetrates the skin of the fruit, laying 2-3 eggs per fruit on average, a single female can lay around 350 eggs (USU, 2009; Kanzawa 1939). The average number of eggs laid per female per day was 7-16 (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 lasted 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).
Eggs hatch in 20-92 hours (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 4 days or more (Kanzawa 1939). The larvae mature in about 3-13 days (Kanzawa 1939). The larvae 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 appear in early April and are most numerous in June-July and September-October (Kanzawa 1939). The males lived 14-29 days and the females 20-48 when fed on cherry (Kanzawa 1936). They live for 21-66 days in May-August, but those emerging from late September onwards overwinter and sometimes survive until the following July (Kanzawa 1939). They enter hibernation in sheltered places in late November at about 5 degrees C (Kanzawa 1939).

D. melanogaster is common in locations where fermentation takes place. Adults are therefore very common in breweries, wineries, wine cellars, around over-ripe fruit under trees, fruit markets and around fruit bowls. They are known to transmit micro-organisms, particularly in grapes (CPC, 2007) (accessed 18/03/2009). There is not much known about the life cycle of *D. melanogaster* under natural conditions (CPC, 2007). *D. melanogaster* does not infect intact fruit, it only attacks fruit that is fermenting. In contrast, *D. suzukii* attacks intact healthy fruit.

Vector

The vectoring capabilities of *D. suzukii* are currently unknown. Many hundreds of different fungal species have been isolated from the guts of wild drosophilids, many of these species in fact first being described from such a source. Drosophilids have been implicated as vectors of plant pathogenic fungi and of plant pathogenic bacteria (EOL, 2009). A major role of *D. melanogaster* in the ecosystem is that it is an effective vector for microorganisms, bacteria and fungi (EOL, 2009).

6.2.1.3 Hosts

Fruits attacked by *D. suzukii* include apple, blueberry, cane berries, cherry, grape, peach, persimmon, plum and strawberry (ODA, 2009; Kanzawa, 1939), wild blackberries, red raspberries, marionberries, strawberries, plums, figs, hardy kiwis and Asian pears (Dreves *et al*., 2009), wild *Rubus* (Kanzawa 1936). It also attacks tomato in the laboratory (ODA, 2009)

6.2.1.4 Plant parts affected

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

6.2.1.5 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).

6.2.1.6 Hazard identification conclusion

Drosophila suzukii has been recorded on grapevine, and is associated with fruit. It is present in China and is not known to be present in New Zealand. Therefore, *D. suzukii* is considered to be a potential hazard.

6.2.2 Risk assessment

6.2.2.1 Entry assessment

In Cherry, females oviposit in ripe fruit hanging on the tree. Fresh fruit can harbour viable eggs, larvae and pupae. Egg laying occurs near harvest and early symptoms are subtle, it is very easy for infested fruit to be transported undetected. Oviposition scars are very small and eggs are difficult to detect (ODA, 2009). The eggs and larvae are killed by 4 days' exposure to temperatures just above freezing point (Kanzawa 1936). Unidentified *Drosophila* spp have been intercepted 47 times on grapes coming from Australia, Chile and the USA, one interception from Australia was identified as *D. melanogaster*. Moreover, there were 3 *Drosophila* spp. interceptions on peaches from China, 2 of which were alive and one of unknown viability (QuanCargo, accessed 07/04/2009). Recently it has established in USA.
Vinegar flies are sensitive to desiccation and die within 24 hours in the absence of water (USU, 2009). Grapes are cold stored before they are shipped to New Zealand. The distribution within China is unclear.

Given that:

- adults, which are very mobile, are likely to be disturbed and leave the fruit during harvest;
- eggs, larvae and pupae can be present inside grape berries;
- oviposition wounds are tiny and can easily be missed during normal packing process;
- the eggs, larvae and pupae need to survive general packing process and storage.

The likelihood of entry is low and therefore non-negligible

6.2.2.2 Exposure assessment

D. suzukii has a wide range host. *Drosophila* flies are common in locations where fermentation takes place. Adult *Drosophila* flies are very common around over-ripe fruit and around fruit bowls. Hosts commonly occur in New Zealand in commercial and backyard situations.

Given that:

- larvae and pupae in infested fruit would need to mature inside the berries;
- host plants occur widely, both in commercial and domestic situations;

The likelihood of exposure is moderate and therefore non-negligible

6.2.2.3 Establishment assessment

D. suzukii has recently established in the USA, indicating there is no clear climatic barrier to establishment into New Zealand. It is also present in Japan. The behaviour of *Drosophila* vinegar flies is simplistic. They are easily drawn towards the smell of any food source, and will mate almost indiscriminately with any individual of the opposite sex. Reproduction is sexual. Females lay 2-3 eggs per fruit on average, a single female can lay around 350 eggs. As many as 65 adults may emerge from a single cherry.

Given that:

- reproduction is sexual, but multiple larvae in one single fruit and adult longevity;
- recently established in the USA and is already present in Japan

The likelihood of establishment is high and therefore non-negligible

6.2.2.4 Consequence assessment

Economic consequences

The percentage of cherry fruits infested ranges up to 75% (Kanzawa, 1936). *D. suzukii* thrives at cooler temperatures. Fungal and bacterial infections and secondary pests may contribute to further fruit deterioration. The establishment of this species could disrupt current IPM measures and disrupt market access. Moreover, *D. suzukii* has a wide range of hosts that are of economic importance for New Zealand. This fruit fly attacks intact ripe fruit.

Given that:

- there would be significant reduction in yield in many crops;
- treatment costs would be increased for many crops;
- there would be reduced market access overseas for many of New Zealand's export crops;

The potential economic consequences of establishment are considered to be moderate and therefore non-negligible

Environmental consequences

D. suzukii is capable of infecting wild *Rubus* species, as well as many amenity species. It is assumed that *D. suzukii* is similar to *D. melanogaster* . *D. melanogaster* is an effective vector for microorganisms, bacteria and fungi (EOL, 2009). These effects are only known from fruit orchards and vineyards.

Given that:

- *D. suzukii* could infect some amenity species
- *D. suzukii* is more likely to infest fruit and vegetable crops, or orchards;

The potential environmental consequences of establishment are expected to be low but non-negligible

Human health consequences

Reproduction in *Drosophil*a is rapid. A single pair of flies can produce hundreds of offspring within a couple of weeks (Miller, 2000). The infestation of *Drosophila* in homes sometimes becomes a nuisance (EOL, 2009).
The potential human health consequences of establishment are considered to be negligible

6.2.2.5 Risk estimation

The likelihood of entry is considered low. The likelihood of exposure is considered moderate for *D. suzukii*. The likelihood of establishment is considered high. The potential economic consequences of establishment are considered moderate. The potential environmental consequences of establishment are considered low.
As a result the risk estimate for D. suzukii is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.

6.2.2.6 Assessment of uncertainty

The information regarding *D. suzukii* is limited. The comparison with *D. melanogaster* results in added uncertainties. There is very limited knowledge about *Drosophila* flies in their normal environment. Most of the data known about *D. melanogaster* is from laboratory strains, which can vary significantly from wild-type strains. It is currently unknown if there are eradication possibilities for *D. suzukii*.

6.2.3 Risk management

6.2.3.1 Options

Pest free area

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *D. suzukii*.

Cold Treatment

No difference was observed in thermal tolerance between the cool and warm-temperate strains of *D. suzukii*. In Japan, *D. suzukii* was found at localities with mean winter and summer temperatures of -5.1°C and 28°C, respectively. In laboratory testing, the lethal temperatures at which half of the adult flies died after 24 hours were 0°C and 32°C.The adult overwintering stage is more cold tolerant than any other developmental stages. Different strains of *D. suzukii* showed similar cold tolerance. The capacity of *Drosophila* species to increase cold tolerance seems to be limited. *D. suzukii* may overwinter in man-protected warm places. The lethal temperatures after 24 hours are depicted in table 1. (Kimura, 2004)

	Cold			Heat		
	LT_{25}	LT_{50}	LT_{75}	LT_{25}	LT_{50}	LT_{75}
Female	-1.1°C	-1.6°C	-1.8°C	32.3°C	32.6°C	32.9°C
Male	0.5°C	0.1°C	-0.7°C	31.6°C	32.2°C	32.6°C

The eggs and larvae were killed by 4 days' exposure to temperatures just above freezing point (Kanzawa 1936). Cold treatment is considered a viable option.

Bagging

The male body is 0.7-0.94 mm in width, while the female body is 0.85-1.24mm. The different live stages of *D. suzukii* are very small. Bagging is currently not considered a viable single option.

Offshore Methyl bromide fumigation followed by cold treatment

The biology of *D. suzukii* is comparable to the Tephritidae fruit flies in that it is an internal feeder. There are some differences, for instance *D. suzukii* forms pupae within the fruit, which could be more resistant. For table grapes coming into the USA, a methyl bromide fumigation followed by cold treatment is currently used as a treatment against *B. dorsalis* (HAL, 2008). The fumigation times and cold treatment times can vary. There are currently three treatment schedules with different combinations of fumigation and cold treatments accepted by USDA-PPQS (TQAU USDA, 2008):

Table 9. Treatment T108-a-1

Temperature (ºC)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
21.11 ºC or above	**32**	**25**	**18**
Followed by a cold treatment			
Temperature (^{O}C)	Exposure period		
0.56 to 2.77^{O}C	**4 days**		
OR 3.33 to 8.33^{O}C	**11 days**		

Table 10. Treatment T108-a-2

Temperature (ºC)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:		
		0.5 hr	2 hrs	2.5 hrs
21.11 ºC or above	**32**	**25**	**18**	**18**
Followed by a cold treatment				
Temperature (^{O}C)	Exposure period			
1.11 to 4.44^{O}C	**4 days**			

OR 5 to 8.33^{O}C	**6 days**
OR 8.88 to 13.33^{O}C	**10 days**

Table 11. Treatment T108-a-3

Temperature (ºC)	Rate (g/ m^3)	Minimum concentration readings (g/m3) at:			
		0.5 hr	2 hrs	2.5 hrs	3 hrs
21.11 ºC or above	**32**	**25**	**18**	**18**	**17**
Followed by a cold treatment					
Temperature (^{O}C)	Exposure period				
6.11 to 8.33^{O}C	**3 days**				
OR 8.88 to 13.33^{O}C	**6 days**				

The United States has required that the efficacy of commodity treatments for certain pests, especially fruit flies, meets or exceeds a Probit 9 statistical standard. To meet this standard, treatment must kill 99.9968 percent of the pests in a test of at least 100 000 individual pests. This treatment schedule is described as being suitable for tarpaulin or chamber fumigations however no treatment efficacy level is provided. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *D. suzukii* on table grapes or if evidence is provided of the efficacy against *D. suzukii* on table grapes, then methyl bromide fumigation followed by cold treatment is considered a viable option.

Visual inspection.

Pre-export visual inspection of the consignment for oviposition punctures should reveal old puncture sites but it may be difficult to detect a new puncture in very recently infested fruit, especially in a bunch of grapes. The efficacy of detecting fruit fly infested fruit can be lower than for some other insects. Early symptoms are subtle, it is very easy for infested fruit to be transported undetected. Emerging adults on the fruit surface may be detected on arrival in New Zealand. Pre-export visual inspection will assist in reducing the likelihood of entry but is not considered to be sufficient as a single viable phytosanitary measure.

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7 Risk assessment of potential hazards – Hemiptera (aphids, bugs, mealybugs, scale, whitefly)

7.1 *Apolygus lucorum* – small green plant bug

Scientific name: *Apolygus lucorum* (Meyer-Dür, 1843) (Hemiptera: Miridae)
Other relevant scientific names: *Lygus lucorum* (Meyer-Dür); *Lygocoris lucorum* (Meyer-Dür)
Common name: small green plant bug

7.1.1 Hazard identification

7.1.1.1 New Zealand status

Apolygus lucorum is not known to be present in New Zealand. Not recorded in: Larivière and Larochelle (2004), CPC (2007), PPIN (2009).

7.1.1.2 Biology

Apolygus lucorum is green and rather broadly oval in shape. The adult is 5–6mm in length and is found from July to October (in Britain) (Nau, 2006).

Nymphs and adults feed by piercing and sucking the juices of both vegetative and reproductive plant tissues on a wide range of plants including species of economic importance and weeds. Recent studies on biology and population dynamics have been carried out in China as *A. lucorum* has emerged as an increasingly important pest of transgenic (Bt) cotton (for example Lu *et al*, 2008, 2009).

In China, *A. lucorum* is multivoltine, the number of generations presumably influenced by factors such as temperature: Jiangsu, tea plantations: 4 generations (Xu, 1993); Shandong, Heze municipality, grape vines: 4–5 generations (Liu *et al*, 2004); cotton, coastal areas of Jiangsu: 5 generations (Wang, 1984); kenaf and jute, Zhejiang Province: 5 generations (Fang *et al*, 1983); cotton: 3–5 generations per year (Chu and Meng, 1958). Different generations may be found on different hosts depending on the phenology of the plants.

A. lucorum overwinters as eggs in sheltered sites such as straw, weeds, lucerne stems, the branch crotch of apple, pomegranate and peach trees, and trunks and branches of mulberry, or even sometimes in the soil (Liu *et al*, 2004; Xu, 1993; Fang *et al*, 1983; Chu and Meng, 1958). Overwintering has been observed to start in early autumn (Wang, 1984).

Adults have been observed to appear on grapevines in early April (Liu *et al*, 2004). Wang (1984), in a study on cotton in coastal areas of China, noted a peak of first generation adults in mid to late May with that of the second generation adults in June to early July. In Jiangsu, second and third generation adults reproduce mainly on weeds, and the final generation adults peak in late October (Xu, 1993).

A. lucorum is a strong flier and will travel some distance to suitable food plants (Chu and Meng, 1958). All mirids are very active, running and hopping with short rapid flights when disturbed (Fletcher, 2007), and are typically good dispersers. It is assumed that *A. lucorum* has sex pheromones as these have been identified for other mirid species (Zhang and Aldrich, 2008).

In grapevines, both the nymphs and adults of *A. lucorum* damage young shoots and leaves causing withering and perforation (Lee at al, 2002; Liu *et al*, 2004). It also damages the young fruit of grapevines, causing rust (Liu *et al*, 2004), black spot, corky scar and shattering (Lee *et al*, 2002). It is unclear if *A. lucorum* attacks the mature fruit of grape or if the damage is only inflicted while the fruit is developing. In Korea, a total of 71% of grapevine fields were affected, with damage being particularly severe in the chief grape-producing districts (Lee *et al*, 2002).

In tea plantations, rainfall was the dominant climatic factor influencing outbreaks of *A. lucorum* (Xu, 1993). The pest preferred to feed on younger buds of the host plant (Xu, 1993).

7.1.1.3 Hosts

Polyphagous, including:

Vitis vinifera (grape) (Lee *et al*, 2002); *Gossypium* (cotton) (Lu, 2009; CPC, 2007); *Camellia sinensis* (tea) (Xu, 1993); *Vigna radiatus* L. (mungbean) (Lu *et al*, 2009); *Phaseolus vulgaris* (Lu *et al*, 2008b (in CAB Abstracts)); *Prunus* (cherries) (Watanabe, 1995, 1996 (in CAB Abstracts)), *Prunus avium* (sweet cherry) (CPC, 2007); *Humulus lupulus* (hops) (Sedivy *et al*, 1999); chrysanthemum (Miyata, 1994); *Daucus* carrot (Zhang, 1989); *Morus* (mulberry) (Fang *et al*, 1983), *Hibiscus cannabinus* (kenaf) (Fang *et al*, 1983), *Impatiens balsamina* (Lu *et al*, 2009), *Forsythia koreana* (Lee *et al*, 2002).

7.1.1.4 Plant parts affected

Young shoots, leaves and fruits (Lee *et al*, 2002). In Shandong, China, nymphs and adults attack the leaves, inflorescence stalk and berries of grapevines (Liu *et al*, 2004).

7.1.1.5 Geographic distribution

Africa (ITIS, 2009), Europe (including Britain (Nau, 2006) and Denmark), and Northern Asia (including China (Lu *et al*, 2009, 2008; Xu, 1993; Wang, 1984), Korea (Lee *et al*, 2002) and Japan), and North America (native in Canada and Continental US (ITIS, 2009)).

7.1.1.6 Hazard identification conclusion

Apolygus lucorum has been recorded on grapevine and is associated with the fruit. It is present in China and it is not known to be present in New Zealand. Therefore it is considered to be a potential hazard.

7.1.2 Risk assessment

7.1.2.1 Entry assessment

Both nymphs and adults have been recorded as damaging the fruit of grapes although they are primarily found on young shoots and leaves of host plants. It is uncertain at which stage of fruit development they are present but given they prefer young tissues, *A. lucorum* is more likely to be present when the fruit is at an early stage of development. If adults are present when fruit is mature, they are likely to be dislodged at the time of harvest because mirids are typically very active and are likely to run, hop or fly when disturbed. If nymphs are present at the time of harvest then high levels of infestation are likely to produce fruit that would be rejected because of its appearance. It is possible that nymphs could be overlooked during standard grading and packing process if present at low levels. It is uncertain if eggs would be associated with the commodity, but if so it is assumed that they are very small and therefore it is likely they would be undetected.

Given that:

- adults, which are very mobile, are likely to be disturbed and leave the fruit during harvest;
- it is unclear if nymphs are associated with mature fruit but if present may be overlooked at low infestations if concealed within the grape bunch;
- it is uncertain if eggs are associated with the commodity but, if present, they could be overlooked due to their small size;
- damaged grapes will be discarded during the harvest and packing process;

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

7.1.2.2 Exposure assessment

Following post-border distribution of imported grapes, any associated *A. lucorum* need to disperse and locate suitable hosts. Eggs would need to hatch while the fruit is in a suitable condition and develop through to a mobile stage, before the fruit decomposes. Because nymphs and adults feed on the fruit of the grape, there is potential for continued development and survival after harvest whilst remaining in the bag that the bunch is packed in. Once the consumer (or sometimes the retailer) has removed grapes from the bag there is potential for adults to fly to suitable hosts. Pedicels, peduncle and uneaten berries will be thrown away, especially if they appear damaged. If these are thrown in compost heaps, then nymphs may have the opportunity to finish development through to adult and disperse. Nymphs are mobile and could walk away from the discarded fruit or remains as fruit quality degrades. *A. lucorum* is polyphagous and there may well be non-commercial grapes or other suitable host plants in nearby gardens or wasteland. It is uncertain how far nymphs can actively disperse, but it is assumed that suitable host plants would need to be fairly close to the discarded grape remains.

Given that:

- discarded fruit would need to remain in suitable condition to allow development of immature stages of *A. lucorum* to the adult stage which is capable of dispersing to nearby hosts
- nymphs could walk to suitable hosts if these are close to the discarded fruit
- *A. lucorum* is polyphagous and acceptable hosts may be available in modified habitats

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

7.1.2.3 Establishment assessment

For sexual reproduction to take place, male and female bugs must encounter each other. It is assumed that *A. lucorum* has sex pheromones as these have been identified for other mirid species (Zhang and Aldrich, 2008). This would increase the chance of a male and a female finding each other. *A. lucorum* is a strong flier and will travel some distance to suitable food plants (Chu and Meng, 1958). This species is polyphagous on a wide range of plants including plants of commercial interest such as cherries (*Prunus*), garden plants, and weeds. The known geographic distribution of this species, which includes temperate countries in the northern hemisphere, suggests that this species would be able to establish throughout New Zealand.

Given that:

- reproduction is sexual so at least one individual of each sex is required to start a reproducing population;
- it is likely that pheromones would facilitate mate finding;
- larvae are polyphagous, feeding on grapes, plums and other introduced plant species that appear in New Zealand's modified environments;
- the known distribution of *A. lucorum* suggests that climate would not be a barrier to establishment in New Zealand;

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

7.1.2.4 Consequence assessment

Economic consequences

In Korea, a total of 71% of grapevine fields were affected by this species, with damage being particularly severe in the chief grape-producing areas (Lee *et al*, 2002). Damage to leaves, stems and fruit would directly impact on vine productivity. *A. lucorum* is polyphagous and has the potential to damage other crops including stonefruit (*Prunus* spp.). Indirect consequences could include an increase in pest control costs and/or disruption of existing control programmes, particularly those based on IPM. The establishment of *A. lucorum* could also cause disruption of access to some of New Zealand's export markets. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- damage by *A. lucorum* could decrease productivity of grapes and possibly other commercial crops if not controlled;
- controlling *A. lucorum* could increase treatment costs for grape and other crops in New Zealand;
- there could be reduced market access overseas for some of New Zealand's export crops;

The potential economic consequences are considered to be low to moderate and therefore non-negligible.

Environmental consequences

A. lucorum is polyphagous with recorded hosts occurring across a number of different plant families. A number of the recorded hosts or species in the same genera occur in New Zealand as exotics that are either commercial crops (for example *Prunus* spp.), garden plants, of casual occurrence in the wild, or fully naturalised (for example *Prunus* spp., *Morus* (mulberry), *Impatiens, Camellia, Forsythia*. Some of the recorded hosts have native (but not endemic) relatives in New Zealand (for example *Hibiscus*) and these species may be susceptible to damage from *A. lucorum*.

Given that:

- *A. lucorum*, which is polyphagous, could attack garden and amenity plants that are grown in New Zealand;
- *A. lucorum* could attack some native plant species;

The potential environmental consequences are considered to be low and therefore non-negligible.

Human health consequences

There are no known human health consequences.

7.1.2.5 Risk estimation

The likelihood of entry is considered to be low, the likelihood of exposure is considered to be low and the likelihood of establishment is considered to be moderate. The potential economic consequences are considered to be low to moderate, the potential environmental consequences are considered to be low, and there are no known health consequences. *As a result, the risk estimate for* Apolygus lucorum *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

7.1.2.6 Assessment of uncertainty

Whether *A. lucorum* is associated with the commodity at harvest and which life stages might be present is uncertain. The biology of *A. lucorum* is not well documented. For example, how far nymphs will disperse is not known, nor the size of the eggs, nor if the females produce a sex pheromone. How the nymphs and adults respond to prolonged periods at low temperatures is unknown, however they are not likely to survive such conditions because the eggs are the overwintering stage and overwintering is initiated in autumn.

7.1.3 Risk management

7.1.3.1 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 freedom

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Since the current distribution of *A. lucorum* in vineyards is unclear, pest free area status may be an option for table grapes exported from some provinces. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *A. lucorum*.

Methyl bromide fumigation

The plant protection and quarantine department of the USDA currently recommends one of the following methyl bromide treatments against external feeders on grapes from Chile (TQAU USDA, 2008)

Table 12. Treatment T101-i-2-1

Temperature (ºC)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
26.67ºC or above	24	19	14
21.11 to 26.11ºC	32	26	19
15.56 to 20.56ºC	40	32	24
10.00 to 15.00ºC	48	38	29
4.44 to 9.44ºC	64	48	38

The treatment duration has been changed to 3 hours (as of 24/01/2006). The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, treatment must kill 99.9968% of the pests in a test of at least 100 000 individual pests. This treatment schedule is described as being suitable for tarpaulin or chamber fumigations, however no treatment efficacy level is provided. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *A. lucorum* or if evidence is provided of the efficacy against *A. lucorum* on table grapes, then methyl bromide fumigation is considered a viable option.

Bagging

Individual bagging of fruit would prevent nymphs and adults moving onto grape bunches to feed, and eggs being laid on or very close to bunches. However, bagging will only be a viable risk mitigation option if the bags are in place during the whole growing season, right up until harvest of the grapes. If bagging occurs until harvest it is considered a viable option combined with pre-export phytosanitary visual inspection.

Pre-export phytosanitary visual inspection

Eggs are unlikely to be detected due to their size, especially if present in low numbers. Nymphs may be difficult to detect if present in very low numbers, due to their small size and the possibility of concealment within the grape bunches. Scarring of the fruit and other feeding signs may alert inspectors to their presence. For high infestations this would certainly be the case. Pre-export phytosanitary visual inspection will assist in reducing the likelihood of entry and together with bagging is considered a viable option.

7.2 *Maconellicoccus hirsutus* – pink hibiscus mealybug

Scientific name: *Maconellicoccus hirsutus* (Green, 1908) (Hemiptera: Pseudococcidae)

Other relevant scientific names: *Phenacoccus hirsutus; Phenacoccus quaternus; Pseudococcus hibisci; Phenacoccus glomeratus; Pseudococcus crotolariae; Spilococcus perforatus; Paracoccus pasaniae; Maconellicoccus perforatus; Maconellicoccus pasaniae*

Common names: pink hibiscus mealybug, hibiscus mealybug, pink mealybug, hirsutus mealybug, grape mealybug, mulberry mealybug, cochenille de l'Hibiscus

7.2.1 Hazard identification

7.2.1.1 New Zealand status

Maconellicoccus hirsutus is not known to be present in New Zealand. Not recorded in: Cox (1987), Ben-Dov (1994), PPIN (2009).

7.2.1.2 Biology

M. 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. 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 life stages and this can occur inside fruit bunches, bark crevices or in the soil. Both sexual and parthenogenetic 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; Meyerdirk *et al*, 2002; Mani, 1989).

In general, *M. hirsutus* forms colonies on the host plant. It prefers apical and tender regions of the plant, but the older plant parts may also harbour large populations. As it feeds, *M. hirsutus* injects 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).

For grapes, Manjunath (1985, cited in Williams, 1996) has reported that in severe attacks, up to 90% of the grape clusters have been 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).

7.2.1.3 Hosts

M. hirsutus is highly polyphagous: Ben-Dov (1994) records 98 host genera/species in 36 families; Meyerdirk and others (2001) record over 200 genera of plants in 70 different families. It 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). Some hosts enable the insect to complete its entire life cycle while others are only suitable for feeding. Grape (*Vitis vinifera*) is a host (Williams, 1996).

7.2.1.4 Plant parts affected

Leaves, shoots, fruit (Meyerdirk *et al*, 2001; CPC, 2007).

7.2.1.5 Climate

Almost all the serious damage by *M. hirsutus* is in areas between 7^{o} and 30^{o}N, where there are reports of seasonal differences in the incidence of the pest (Williams, 1996). However, Williams (1996) suggests that because *M. hirsutus* is known as far north as Lebanon in the Middle East, outbreaks of this species in the West Indies pose a threat to the more temperate areas of the USA where cotton and grapes could be susceptible; these crop plants are prone to attack in India and Egypt (Mani, 1989; Amin and Emam, 1996). Williams (1996) goes on to say: “*Phenacoccus madeirensis* (Green), a polyphagous and normally tropical mealybug found throughout Central and Southern America and in Africa is known from many parts of Mexico and USA. This species was first reported from Sicily by Longo and Russo (1990) and later infesting many plants there (Mazzeo *et al*, 1994). There seems to be no reason why *M. hirsutus* could not similarly survive in southern Europe and southern USA.” *M. hirsutus* has been detected since in California and Florida in the US (Hoy *et al*, 2006; Kairo *et al*, 2002).

7.2.1.6 Geographic 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, Mexico, Belize in Central America, and Guyana and Venezuela in South America (Hoy *et al*, 2006; Goolsby *et al*, 2002; Kairo *et al*, 2002; Williams, 1996;).

M. hirsutus is present in China (Ben-Dov, 1994; Williams, 1996; CPC, 2007; ScaleNet, 2009), native, not invasive, and of restricted distribution (CPC, 2007). In China, *M. hirsutus* has been reported from Shanxi, Zhejiang and Guangdong, with *Vitis* being mentioned as one of the hosts (Hua, 2000).

7.2.1.7 Hazard identification conclusion

M. hirsutus has been recorded on grapevine, and is associated with the fruit. It is present in China and is not known to be in New Zealand. Therefore it is considered a potential hazard.

7.2.2 Risk assessment

7.2.2.1 Entry assessment

M. hirsutus is recorded as a pest of grape vines in China although its prevalence throughout the grape growing regions is not clear. Life stages tend to cluster together in colonies. Although the young nymphs which are mobile tend to have a preference for young tender plant parts, eggs, nymphs and adults can be found on all plant parts including fruit. Females choose protected places for egg sacks; presumably the interior of grape bunches would provide such shelter. The whitish cottony egg sack, 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 egg sacks, nymphs and adults tend to be very visible on the host (Meyerdirk *et al*, 2001). Most infested fruit are likely to be detected and discarded during the harvest and packing processes.

M. hirsutus has not been intercepted at the New Zealand border, although present in Australia. However other mealybugs (for example *Pseudococcus longispinus*) have been intercepted on fresh grapes from Australia, USA and Chile (MAFBNZ, 2009), indicating that this is a potential pathway. It is assumed that *M. hirsutus* would be able to survive the pathway from China to New Zealand.

Given that:

- *M. hirsutus* is present on grapevine in China but its prevalence through grape growing regions is not clear;
- life stages of *M. hirsutus* have a preference for young tender plant parts but can be found on fruit;
- heavy infestations are highly visible and damaged fruit would be discarded;
- low infestations may go undetected if small life stages of the scale occur hidden inside the grape bunch;
- *M. hirsutus* has not been detected at the New Zealand border but other mealybug species have been intercepted on table grapes from other pathways;

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

7.2.2.2 Exposure assessment

Because nymphs and adults feed on the fruit of the grape, there is potential for continued development and survival after harvest whilst remaining in the bag that the bunch is packed in. Once the consumer has removed grapes from the bag, pedicels, peduncle and uneaten berries will be thrown away, especially if they appear damaged. If these are thrown in compost heaps or the environment, then adults, crawlers and nymphs have some opportunity to reach 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 (Bartlett (1978)). The primary dispersal stage for mealybugs is the mobile crawler which can move short distances actively or long distances passively (Bartlett, 1978; James, 1937). Field experiments showed that another mealybug species (*Pseudococcus maritimus*) 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). These results indicate that movement of *M. hirsutus* by walking is likely to be extremely slow. First instars of other species in the same family 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). 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. Some mealybugs may be carried to new host plants by ants (Beardsley *et al*, 1982), and *M. hirsutus* is known to be attended by ants (Meyerdirk *et al*, 2001). 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).

M. hirsutus is extremely 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 egg laying sites;
- *M. hirsutus* is extremely polyphagous, and suitable host species are widely distributed;

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

7.2.2.3 Establishment assessment

Both parthenogenesis and sexual reproduction have been noted to occur in this species, although researchers have observed regional differences. Which of these reproductive strategies (or both) would be likely to occur in populations sourced from China is unknown. If sexual reproduction is necessary then the possibility of males and females encountering each other would be facilitated by females releasing a sex pheromone that can attract the male from up to several hundred metres (Meyerdirk *et al*, 2001). Solely parthenogenic populations have been reported (for example in Bihar, India) (cited in Williams, 1996) and this would greatly increase the likelihood of establishment.

Females can lay hundreds of eggs. Crawlers, ovisacs and males may migrate by means of air currents; females (which are non-flying), crawlers and nymphs are mobile and can walk from host to host in the infested area (Meyerdirk *et al*, 2001). This species is polyphagous on a huge variety of plants including plants of commercial interest, garden plants and weeds in New Zealand, therefore, suitable hosts are highly likely to be readily found.

M. hirsutus is found predominantly in tropical and subtropical zones. An assessment of climate suitability (Anonymous, 2002) found that *M. hirsutus* is unlikely to survive in New Zealand in most years because temperatures are not warm enough to supply sufficient day degrees for a single generation to develop. However, in the absence of specific information, this was calculated by assuming a similar temperature threshold to the related tropical mealybug *P. manihoti*, and it is suggested that the ability of *M. hirsutus* to develop may be slightly underestimated. Nevertheless, it would appear that a generation could be completed in a very warm year in the Hawkes Bay region, suggesting that short-term establishment could be a possibility in this area. A population may not persist through a cool year. The report (Anonymous, 2002) does not appear to have assessed any site in New Zealand north of Auckland in terms of temperature but it does mention that a negative correlation with relative humidity was observed and that the North Island conditions are unlikely to be conducive to significant population development. Populations could possibly establish under glass, particularly if the source population exhibits parthenogenic reproduction which would allow a single individual to found a reproducing population. 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:

- *M. hirsutus* populations reproduce either sexually or asexually, or a combination of the two strategies;

- mate finding in sexually reproducing populations is assisted by female production of pheromones;
- *M. hirsutus* would be likely to have a very limited distribution due to climatic factors;
- plants in commercial glasshouses are unlikely to be exposed to *M. hirsutus*;

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

7.2.2.4 Consequence assessment

Economic consequences

If *M. hirsutus* were to establish in New Zealand its extreme polyphagy indicates the potential in some areas for significant damage to plants of economic interest, including fruit (for example grapes, passionfruit, *Citrus* spp., guava), vegetables (for example asparagus, beetroot, sweet pepper, cucurbits, carrots, kumara, avocado) and others. The impacts will be limited by the lack of ability for *M. hirsutus* to establish through much of New Zealand. Establishment could result in the need for expensive eradication programmes, or increased compliance costs for exports to countries without *M. hirsutus*. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- damage by *M. hirsutus* would decrease productivity of a number of commercial crops if not controlled;
- controlling *M. hirsutus* could increase treatment costs a number of commercial crops in New Zealand;
- establishment of *M. hirsutus* in New Zealand could cause disruption of access to some markets
- *M. hirsutus* would be likely to have a very limited distribution due to climatic factors;

The potential economic consequences are considered to be low and therefore non-negligible.

Environmental consequences

M. hirsutus is extremely polyphagous, and some native species are in the same genera as known hosts for *M. hirsutus* (for example *Passiflora tetrandra*). Based on known attacks on native plants by exotic species in New Zealand, sap-sucking hemipterans such as mealybugs, particularly polyphagous species, could be a high risk group for native flora (Beever *et al*, 2007). The displacement of native mealybug species is another possible consequence of establishment. Although *M. hirsutus* could find many suitable native host plants if it were to establish in New Zealand, its environmental impacts would be overall limited due to its very restricted distribution in areas with suitable climate.

Given that:

- *M. hirsutus* is extremely polyphagous and is likely to find suitable native host plants as well as attacking many garden and amenity plants that are grown in New Zealand;
- *M. hirsutus* could displace native mealybug species;
- *M. hirsutus* would be likely to have a very limited distribution due to climatic factors;

The potential environmental consequences are considered to be low and therefore non-negligible.

Human health consequences

There are no known human health consequences.

7.2.2.5 Risk estimation

The likelihood of entry is considered to be low, the likelihood of exposure is considered to be moderate, and the likelihood of long-term establishment is considered to be low. The potential economic consequences are considered to be low, the potential environmental consequences are considered to be low, and no impact on human health has been detected. *As a result the risk estimate for* Maconellicoccus hirsutus *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

7.2.2.6 Assessment of uncertainty

The prevalence of *M. hirsutus* throughout the China grape growing regions is unknown.

Climate assessments for likelihood of *M. hirsutus* establishing and persisting in New Zealand have assumed a similar temperature threshold to *P. manihoti*, however should *M. hirsutus* have lower temperature requirements then the ability of *M. hirsutus* to survive may be underestimated. In addition, climate change may enhance the ability of *M. hirsutus* to survive in New Zealand.

7.2.3 Risk management

7.2.3.1 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 or places of production

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. The distribution of *M. hirsutus* in China is restricted. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *M. hirsutus*.

Bagging

Individual bagging of fruit may protect it from infestation by *M. hirsutus*. However, bagging will only be a viable risk mitigation option if the bags are in place during the whole growing season, right up until harvest of the grapes. If bagging occurs until harvest it is considered a viable option when combined with phytosanitary visual inspection.

Sulphur dioxide fumigation

Fumigation with sulphur dioxide ($SO_{2)}$ is used as a mitigating option along other table grape pathways against spiders on table grapes before export to New Zealand. This is used in preference to fumigation with methyl bromide which reduces the shelf life of grapes. Observations from the operation of other table grape import pathways indicate that it is also detrimental to mealybugs (S. Gould, MAFBNZ, New Zealand, pers. comm., 5 May 2009). This treatment would assist in reducing the likelihood of entry of *M. hirsutus*, but sulphur dioxide fumigation is not considered to be sufficient as a single measure to mitigate the risk.

Pre-export phytosanitary visual inspection

M. hirsutus shows a preference for clustering in colonies and the life stages tend to be very visible on the host: eggs, which are pink, are laid in groups in whitish cottony ovisacs attached to the host; the nymphs and adults, which are about 2–3 mm long, are reddish pink, and covered with white mealy wax. Therefore, it is anticipated that pre-export phytosanitary visual inspection of the consignment could detect *M. hirsutus*. Pre-export phytosanitary visual inspection is considered a viable option when combined with bagging.

Cold treatment

Since the development of *M. hirsutus* appears to be limited by temperature, cold treatment will probably have a mitigation effect. A study where grape mealybugs (*Pseudococcus maritimus)* were exposed to low temperatures with slow release sulphur dioxide pads gave a result of 100% mortality after 6 weeks (9567 insects). The insects were tested in plastic cups. A large scale test with insects on grape bunches resulted in 9% survival after 8 weeks of exposure to cold and SO_2 fumigation (3566 insects), indicating the efficacy of this treatment depends on the methodology used (Yokoyama *et al*, 2001). A combined cold and SO_2 treatment is expected to have similar effects on *M. hirsutus*. However, until efficacy on table grapes against *M. hirsutus* is provided, although providing a mitigation effect, this is not considered a viable option.

Methyl bromide fumigation

The plant protection and quarantine department of the USDA currently recommends one of the following methyl bromide treatments against *Pseudococcidae* on grapes (TQAU USDA, 2008) (accessed 23/02/2009):

Table 13. Treatment T104-a-2

Temperature (ºC)	Rate (g/m^3)	Minimum Concentration Readings (g/m3) at:	
		0.5 hr	2 hrs

26.67ºC or above	40	32	24
21.11 to 26.11ºC	48	38	29
15.56 to 20.56ºC	64	48	38

The United States has required that the efficacy of commodity treatments for certain pests, meet or exceed a Probit 9 statistical standard. To meet this standard, treatment must kill 99.9968 percent of the pests in a test of at least 100 000 individual pests. No treatment efficacy level is provided for this specific treatment. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *M. hirsutus* or if evidence is provided of the efficacy against *M. hirsutus* on table grapes, then methyl bromide fumigation is considered a viable option.

7.3 *Nipaecoccus viridis* – spherical mealybug

Scientific name: *Nipaecoccus viridis* (Newstead) (Homoptera: Pseudococcidae)
Other relevant scientific names: *Dactylopius perniciosus*; *Dactylopius viridis*; *Nipaecoccus vastator*; *Pseudococcus perniciosus*; *Pseudococcus solitarius*; *Ripersia theae*; *Trionymus sericeus*
Common names: spherical mealybug, hibiscus mealybug, karoo thorn mealybug

7.3.1 Hazard identification

7.3.1.1 New Zealand status

Nipaecoccus viridis is not known to be present in New Zealand. Not recorded in: Cox (1987), Ben-Dov *et al*. (2006), PPIN (2009).

7.3.1.2 Biology

Nipaecoccus viridis is an important tropical and sub-tropical pest of numerous food, forage, fibre and ornamental crops (biology is according to Sharaf and Meyerdirk (1987), unless stated otherwise). In Israel, it infests all parts of the citrus tree and causes the excretion of large quantities of honeydew, which encourages sooty mould, the appearance of irregular green spots on the fruit and malformed fruit which is rendered inexportable (Gross *et al*, 2000).

N. viridis has been reported to reproduce both sexually and parthenogenetically. 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 beforehand. 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 (Sharaf and Meyerdirk, 1987; 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. The nymphs prefer to remain gregariously beneath the mother colony. The life cycle depends on environmental conditions and the host. A female can lay up to 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 location, but can move away if it is not. Moulting usually occurs while remaining in one place and with each successive moult the nymph moves slightly forward and reattaches itself to a suitable portion of the plant for feeding. Males have five instars and have a development time of about 20 days whilst females have four with a developmental time of about 19 days. *N. viridis* reproduces throughout the year with some retardation of development during the winter months. There are multiple overlapping generations.

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. In contrast, *N. viridis* remains on *Citrus* plants in small numbers over the winter.

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, while overwintering took place as eggs, nymphs or adults (Jarjes *et al*, 1989).

In South African *Citrus* 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 (Ben-Dov *et al*, 2006). 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 *N. viridis* resulted in arrestment of linear growth of the stems and petioles and great reduction and crumpling of the leaves. *N. viridis* secretes large amounts of honeydew, which is often found on leaves, twigs and fruits just below the infestations. The honeydew secretions on the plant parts cause fruits to fall and leaves to turn yellow (Abdul Rassoul, 1970). Heavy sooty mould can grow on the honeydew which can also accumulate dust rendering fruits unmarketable.

7.3.1.3 Hosts

N. viridis is highly polyphagous (CPC, 2007). Hosts have been recorded on at least 45 plant families and 73 genera (Ben-Dov *et al*, 2006; 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 (Ben-Dov *et al*, 2006). *N. viridis* has been reported to cause up to 5% damage in vineyards in Bangalore, India (Mani and Thontadarya, 1987). In India, it 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). *Vitis vinifera* and *Pyrus communis* have been recorded as hosts in Iraq (Abdul Rassoul, 1970).

7.3.1.4 Plant parts affected

Branches, twigs, fruit and leaves (Abdul Rassoul, 1970); all plant parts of *Citrus* (Ben-Dov *et al*, 2006).

7.3.1.5 Geographical distribution

N. viridis is widespread throughout the tropics and subtropics including Africa, parts of Central America, Oceania and Asia (Ben-Dov *et al*, 2006). Because of 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 and Hong Kong (Ben-Dov *et al*, 2006).

7.3.1.6 Hazard identification conclusion

Nipaecoccus viridis has been recorded on grapevine and is associated with the fruit of at least some of its hosts. It is present in China and is not known to be present in New Zealand. Therefore it is considered to be a potential hazard.

7.3.2 Risk assessment

7.3.2.1 Entry assessment

The review by Sharaf and Meyerdirk (1987) states that the damage on *Vitis vinifera* is heavy, but no other literature has been found to confirm this. This, together with its tropical and sub-tropical distribution, suggests that its prevalence in vineyards is likely to be very 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 grape bunches 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 is likely to be discarded.

Given that:

- *N. viridis* is likely to have a very low prevalence, if any, in the vineyards in China;
- grape bunches are less likely to be infested than other plant parts;
- infestation on fruit is likely to be associated with cottony egg sacs and honeydew and will be readily detectable in the pre-export process;

The likelihood of entry is considered to be negligible.

7.3.2.2 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.*

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

7.3.2.3 Assessment of uncertainty

The distribution of *Nipaecoccus viridis* in China and its prevalence in vineyards is uncertain. Moreover, the frequency with which it infests grape bunches is not known.

7.4 *Pinnaspis strachani* – Hibiscus snow scale

Scientific name: *Pinnaspis strachani* Cooley (Homoptera: Diaspididae)
Other relevant scientific names: *Hemichionaspis minor strachani; Hemichionaspis townsendi; Chionaspis aspidistrae gossypii; Hemichionaspis aspidistrae gossypii; Hemichionaspis proxima; Hemichionaspis marchali; Pinnaspis minor strachani; Pinnaspis proxima; Pinnaspis aspidistrae gossypii; Pinnaspis temporaria; Hemichionaspis minor; Pinnaspis aspidistrae gossypii; Pinnaspis gossypii; Pinnaspis marchali; Hemichionaspis gossypii; Chionaspis gossypii; Pinnaspis townsendi*
Common names: Hibiscus snow scale, lesser snow scale, cotton white scale

7.4.1 Hazard identification

7.4.1.1 New Zealand status

P. strachani is not known to be present in New Zealand. Not recorded in: Charles and Henderson (2002); PPIN (2009) (accessed 09 Feb 2009).

It was erroneously included in distribution records of the species for New Zealand (Nakahara, 1982) because of previous confusion surrounding the names *Chionaspis minor* Maskell and *Hemiberlesia minor* var. *strachani* Cooley, and which taxa they represented (Charles and Henderson, 2002).

7.4.1.2 Biology

The snow scale *P. strachani* is a bisexual, multivoltine species (Tenbrick *et al*, 2007) (accessed 09/02/2009). 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 (Meijerman and Ulenberg, 2000) (accessed 02/04/2009).

The scale cover of the adult female is white to grey, oyster shaped and slightly convex (Williams and Watson, 1988). Adult females are 1.5–2.5 mm long. The females undergo three developmental stages and the males five. Development time is approximately 23 days for males and 45 days for females (Fernández *et al*, 1993), but this is dependent on temperature, humidity and rainfall (Beardsley and Gonzalez, 1975). 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 or leaves of the host (Beardsley and Gonzalez, 1975). 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).

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 at the New Zealand border 11 times since 2004, on coconut, bananas and curry leaves from tropical destinations (MAFBNZ, 2009).

7.4.1.3 Hosts

Pinnaspis strachani is an important pest of several economic crops, including grapevine. It is a highly polyphagous species that has been recorded from over 170 host genera belonging to 27 plant families. Palms, Liliaceae and orchids are favoured hosts (AEI, 2008). A combined list of hosts from AEI, ScaleNet and CPC (2007) includes 238 genera from 85 families.

7.4.1.4 Plant parts affected

P. strachani affects vegetative, flowering, fruiting and post-harvest stages of host plants. It is found primarily on twigs, branches and trunks, but may be found occasionally on leaves and fruits (AEI, 2009).

7.4.1.5 Geographic distribution

P. strachani probably originated in the Oriental region, but is now a cosmopolitan species in tropical and subtropical regions, for example Asia, Africa, southern USA, Central and (parts of) South America, the South Pacific (AEI 2008; Williams and Watson, 1988; CPC, 2007). In Europe, it is restricted to glasshouses (for example, France and Hungary (Reiderne and Kozar, 1994; Germaine and Matile-Ferrero, 2005)). The status of *P. strachani* in the United Kingdom is uncertain, due to confusion with *P. aspidistrae*; there are no recent records of *P. strachani* there (AEI, 2008).

P. strachani has been recorded in China, in the provinces Fujian, Guangdong, Hainan, and in Hong Kong (AEI, 2008; ScaleNet 2009)

7.4.1.6 Hazard identification conclusion

P. strachani has been recorded on grape vine, and is associated with fruit. It is present in China and is not known to be present in New Zealand. Therefore, *P. strachani* is considered to be a potential hazard.

7.4.2 Risk assessment

7.4.2.1 Entry assessment

P. strachani has only been recorded from the most southern provinces of China. It is assumed that its prevalence will be low in vineyards in other regions of China that are growing grapes for export.

Scale insects are small and often inconspicuous. *P. strachani* tends to prefer the young growing parts of the plant and is more likely to be found on stems than on the fruit. Heavy infestations cause mummification of fruit and this would be expected to be detected and fruit discarded during the harvest and packing processes. At low infestation levels, they could occur undetected inside the grape bunch which includes the rachis and peduncle as well as the fruit itself. *P. strachani* has been intercepted 11 times since 2004, on coconut, bananas and curry leaves from tropical destinations (MAFBNZ, 2009), which indicates that it may be overlooked during the standard grading and packing process overseas. Females and feeding nymphs are attached to the plant by hair-like mouthparts (Tenbrick *et al*, 2007).

Given that:

- prevalence of the scale could be low in many grape-growing regions;
- *P. strachani* tends to prefer young growing parts of the plant rather than fruit;
- heavy infestations are likely to be detected;
- low infestations may go undetected if small life stages of the scale occur hidden inside the grape bunch;
- females and feeding nymphs are well-attached to the plant;

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

7.4.2.2 Exposure assessment

Following post-border distribution of imported grapes, any associated *P. strachani* would need to disperse and locate suitable hosts. There would be limited opportunities for this because the only mobile stages are the crawlers (first instar nymphs) and short-lived adult males. Crawlers are mobile for a period ranging from minutes to days, but usually a few hours (Tenbrick *et al*, 2007).

Eggs laid on fruit prior to harvest would be expected to have developed beyond the mobile crawler stage prior to entry into New Zealand and disposal in the New Zealand environment. Feeding nymphs would be incapable of moving from the imported grape bunch. Male nymphs that complete development to adult on the imported bunches would have the capacity to disperse from discarded grapes if still alive by that time. Female adults that have developed on the imported grapes would not be able to move. They would have to mate, and lay eggs at the same location on the grape bunch to produce a new generation of crawlers to allow any female stages of *P. strachani* to disperse and locate a new host. The grapes (including rachis and peduncle) would have to stay in good enough condition to support the development of *P. strachani* to the point of having mobile life stages present after the grapes have been discarded in a compost heap or in the environment.

P. strachani is highly polyphagous so it is likely that there would be suitable host plants in the vicinity of compost heaps and other locations where waste material might be discarded. Crawlers 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 and that suitable host plants would need to be very close to the imported grape bunch. 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 (APHIS, 2007).

Given that:

- the only mobile stages of *P. strachani* are first instar nymphs (crawlers) and short-lived adult males;
- eggs on fruit at harvest would be expected to have developed past the mobile crawler stage before exposure could occur, therefore a second generation would have to develop on the imported grape bunch to allow dispersal;
- 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 low and therefore non-negligible.

7.4.2.3 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 mentions *P. strachani* in temperate European countries such as Hungary or France, it has been referred to 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 are 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.

7.4.2.4 Risk estimation

The likelihood of entry is of exposure is low and the likelihood of establishment is negligible. *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*.

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

7.4.2.5 Assessment of uncertainty

There is limited information available about the biology of *P. strachani*. Also the information on the damage of this pest to grapevine is limited. There is considerable uncertainty about the temperature tolerance and possibility for survival in New Zealand. In addition, misidentifications have made records of species distributions less certain.

7.5 *Plautia stali* – brown-winged green bug

Scientific name: *Plautia stali* Scott, 1874 (Heteroptera: Pentatomidae)
Other relevant scientific names: *Nezara amurensis* Reuter; *Plautia crossota stali* Scott
Common names: brown-winged green bug, oriental stink bug

7.5.1 Hazard identification

7.5.1.1 Taxonomy

Several workers in Japan have treated this species as a subspecies of *Plautia crossota* (Rider *et al*, 2002).

7.5.1.2 New Zealand status

Plautia stali is not known to be present in New Zealand. Not recorded in: Larivière and Larochelle (2004), PPIN (2009) (accessed 18/02/2009).

7.5.1.3 Biology

P. stali attacks a wide range of tree fruits and some vegetables. It is green with brown wings (biology is according to Schaefer and Panizzi (2000), unless stated otherwise). The adults overwinter in reproductive diapause. Adults are reddish-brown while overwintering and turn to green when diapause is terminated. Oviposition only occurs in green females (Kotaki, 1998). Diapause is induced by short-day photoperiods. Bugs exposed to 5°C underwent neither body colour change nor oviposition and died more rapidly than those kept at higher temperatures (Kotaki, 1998). At 5°C it takes 10 weeks to reach 50% mortality, while it takes about 30 weeks at 10–20°C (Kotaki, 1998). Critical daylength for ovarian development is around 13.5 hours of light. The lower threshold for development is estimated to be 12.7°C (Fukuda and Fujiie, 1988). For the development from egg to adult, 430 degree-days are needed.

The development period from egg to adult is on average 40.3 days. The eggs hatch after 6.4 days and first till fifth instars take 5.4 days, 6.8 days, 5.4 days, 6.3 days and 10.1 days, respectively (Mau and Mitchell, 1978). First instars are gregarious, inactive and do not feed. There are one to two generations on average, with on rare occasions a third one (Fukuda and Fujiie, 1988). The females are polyandrous (one female mates with many males). Females begin ovipositing 8 days after moulting and one day after mating. The mating frequency influences fecundity and egg fertility (Mau and Mitchell, 1978). The average premating period of newly emerged adults combined with mates from the same age was significantly longer (males 13.8, females 13.0 days) compared to newly emerged adults combined with sexually mature mates (males 7.9 and females 7.1 days) (Mau and Mitchell, 1978). Adults readily migrate to trees bearing fruit and are powerful fliers. Males produce an aggregation pheromone. Caged males strongly attract males and females, peaking at dusk or just before complete darkness. *P. stali*, as with other major fruit bug species in Japan, is dependent on cones from conifer species such as Japanese cedar (*Cryptomeria japonica*) and Japanese cypress (*Chamaecyparis obtusa*) to complete its life cycle (Kiritani, 2007). Fruit is mostly attacked when ripe or near ripening. Fruit bugs are unable to breed on the fruits but injure fruits by adult feeding (Moriya, 1995, cited in Kiritani, 2007). Insecticides appear to be the primary weapon for control.

7.5.1.4 Hosts

Japanese cedar (*Cryptomeria japonica*), Japanese cypress (*Chamaecyparis obtusa*) (Kiritani, 2007), dry soybeans (Kotaki *et al*, 1983), peanuts (Kotaki, 1998), cherry (Morita and Numata, 1999), Paulownias, mulberry (Fukuda and Fujiie, 1988), bean, peach, persimmon, plum, grapevine, pea (Mau and Mitchell, 1978; Schaefer and Panizzi, 2000), guava, strawberry, pomegranate (cited in Schaeffer and Panizzi (2000))

7.5.1.5 Plant parts affected

Fruit is mostly attacked when ripe or near ripe which causes blemishing and often internal damage (Schaefer and Panizzi, 2000). In Japan, fruit bugs (including *P. stali*) are unable to breed on fruits but injure fruits by adult feeding (Moriya, 1995, cited in Kiritani, 2007).

7.5.1.6 Geographic distribution

P. stali is considered a serious pest in areas of south-eastern Asia (Mau and Mitchell, 1978). It is known from Japan (Kotaki, 1998), Taiwan and China (Mau and Mitchell, 1978). It is also known from eastern Russia, Korea and Hawaii (Rider *et al*, 2002; Mau and Mitchell, 1978).

7.5.1.7 Hazard identification conclusion

Plautia stali has been recorded on grape vine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *P. stali* is considered to be a potential hazard.

7.5.2 Risk assessment

7.5.2.1 Entry assessment

P. stali, as with other dominant species of fruit bug that cause considerable damage to a range of fruit in Japan, is dependent on cones from conifers such as *Cryptomeria japonica* and *Chamaecyparis obtusa* to complete their life history (Kiritani, 2007). The nymphs feed on the cones (for example Kubo *et al*, 2008; Tsutsumi *et al*, 2003) and it is assumed that this would be the case in China. So eggs and nymphs are not associated with grapes. It is the adults that are associated with and feed on the fruit (Moriya, 1995, cited in Kiritani, 2007). *P. stali* adults are powerful fliers and readily migrate to plants bearing fruit, such as grapevine. The visible blemishes on the fruit caused by feeding mean that infestations are likely to be detected during harvest procedures. In addition, the insects are likely to fall off the grape clusters when disturbed during harvest procedures (Hanken, 2002). Therefore, it is not reasonable to expect that *P. stali* would be included in commercial shipments of grapes.

Given that:

- only adults are associated with the fruit of grape;
- adult feeding damage causes visible blemishes that would be easily detected during the grape harvest;
- adults are likely to fall off the grape clusters when disturbed during harvest procedures;

The likelihood of entry is considered to be negligible

7.5.2.2 Risk estimation

The likelihood of entry for *P. stali* on table grapes from China is considered to be negligible. *As a result the risk estimate for* P. stali *is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

7.5.2.3 Assessment of uncertainty

There is limited information available about the distribution of *P. stali* within China. Also the information on the damage of this pest to grapevine is limited.

7.6 *Pseudococcus* spp. – mealybugs

Due to similarities in the biology the following *Pseudococcus* species are grouped together , because the biosecurity risk they present is likely to be similar.

Scientific name: *Pseudococcus maritimus* (Ehrhorn, 1900) (Hemiptera: Pseudococcidae)
Other relevant scientific names: *Dactylopius maritimus; Pseudococcus bakeri*
Common names: grape mealybug, ocean mealybug

Scientific name: *Pseudococcus calceolariae* (Maskell, 1879) (Hemiptera: Pseudococcidae)
Other relevant scientific names: *Pseudococcus citrophilus*
Common name: scarlet mealybug

Scientific name: *Pseudococcus longispinus* (Targioni Tozzetti, 1867) (Hemiptera: Pseudococcidae)
Other relevant scientific names: *Dactylopius longispinus*
Common names long-tailed mealybug

7.6.1 Hazard identification

7.6.1.1 New Zealand status

P. maritimus is not known to be present in New Zealand. Not recorded in: Ben-Dov and others (2006) (accessed 09/02/2009). Cox (1977) noted that previous records of this species from New Zealand were based on misidentifications. This species is not present in New Zealand (PPIN, 2009) (accessed 09/02/2009).

P. calceolariae and *P. longispinus* are known to be present in New Zealand. They are recorded in Cox (1987), Ben-Dov and others (2006), PPIN (2009), and are considered to be significant pests in vineyards.

7.6.1.2 Biology

P. maritimus is not known to be present in New Zealand, while *P. calceolariae* and *P. longispinus* are. Therefore the biology will be focused on *P. maritimus*.

P. maritimus overwinters as eggs or crawlers within the loose cottony egg sac under bark scales on scaffold limbs, in other sheltered places on trees, or at the bases of trees (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. Reproduction is sexual.

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 female adults lay eggs from late-April to early-May (Abudujapa and Sun, 2007).

Although *P. maritimus* is a polyphagous species, it has been reported in California mainly as a pest of grape, pear and apricot (Ben-Dov *et al*, 2006).

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*, 2006). 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*, 2006).

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.

7.6.1.3 Virus vector

P. maritimus, *P. longispinus* and *P. calceolariae* are all capable of transmitting grapevine leafroll GLRaV-3, but not GRLVa1 between vines (Petersen and Charles, 1997; Martin *et al*, 2005). These diseases are present in New Zealand vineyards and becoming a serious problem in some areas. First instars are more effective vectors than third instars. A single individual is capable of transmitting GLRaV-3 and infecting a healthy grapevine plant (Douglas and Kruger, 2008). *P. longispinus* has also been shown to be capable of transmitting GLRaV-5 isolates. When a vine is infected by two viruses, the mealybug can act as a filter, creating further infections of only a single virus type. Virus transmission has been shown to occur within 24 hours (Golino *et al*, 2002). *P. longispinus* is capable of vectoring grapevine virus A (CPC, 2007: accessed 06/10/2009).

7.6.1.4 Hosts

P. maritimus is polyphagous, with host plants in at least 42 families (Ben-Dov *et al*, 2006; Beers *et al*, 1993); hosts include tree fruit as well as other rosaceous plants, grapes, ornamental trees and shrubs (Beers *et al*, 1993). Grapes and pears are considered to be the primary hosts.

Host genera include (among others): *Ipomoea, Cyperus*, *Rubus*, *Solanum*, *Rhododendron*, *Cupressus*, *Acacia*, *Trifolium*, *Medicago*, *Magnolia*, *Strelitzia*, *Zantedeschia*, *Ilex*, *Citrus*, *Pyrus*, *Prunus*, *Malus*, *Vitis* (Ben-Dov *et al*, 2006).

7.6.1.5 Plant parts affected

P. maritimus is found mainly on leaves which is its primary feeding location and under rough bark on trunks which is where females go for oviposition (Ben-Dov *et al*, 2006). However, it has been recorded on fruit in grape clusters (Grimes and Cone, 1985).

7.6.1.6 Geographic distribution

P. maritimus is a widespread pest, found in North America, Central America, South America, Europe and Asia. It is found, among others, in the USA, Mexico, Argentina, Brazil, China Indonesia (CPC, 2007; Ben-Dov *et al*, 2006; Abudujapa and Sun, 2007).

P. maritimus is reported from Shandong, Fujian, Guangdong, Guanxi and Jiangsu and it is reported from *Vitis vinifera* (AQSIQ, 2007; Hua, 2000). *P. longispinus* is reported from Fujian, Hong Kong, Guangxi and Yunnan, with *Vitis vinifera* as one of the hosts (Hua, 2000). *P. calceolaria* is reported from north, east, south and central China, Hubei, Guangdong and Hunan (Hua, 2000).

Pseudococcus affinis has been frequently misidentified as *P. maritimus*, leading to numerous records of the latter species from throughout the world (Ben-Dov *et al*, 2006).

7.6.1.7 Hazard identification conclusion

P. maritimus is present in China and is not known to be present in New Zealand. It is associated with grapevines and known to infest fruit, and is therefore classed as a potential hazard in this analysis.

P. longispinus and *P. calceolariae* are present in China and are also known to be present in New Zealand. They are associated with grapevines and known to infest fruit, and known to be capable of vectoring grape viruses; however the grape viruses known to be vectored by these species are already present in New Zealand and therefore they are not classed as potential hazards in this analysis.

7.6.2 Risk assessment

7.6.2.1 Entry assessment

P. maritimus is generally associated with leaves and bark rather than fruit, but it has been recorded on fruit in grape clusters (Grimes and Cone, 1985). Grapes and pears are considered to be the primary hosts. Adult females 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, particularly if present at low levels and contained within the grape bunch. At high infestation levels fruit will become unsightly and will be discarded. Most stages (except eggs, crawlers and adult males) are firmly attached to their host by their piercing mouthparts, and may not be dislodged by brushing fruit.

Live adult *P. maritimus* have been intercepted at the border on apricots from the USA and sea-freighted pears from California (MAFBNZ, 2009), so adults are able to survive long transit procedures. *P. maritimus, P. longispinus* and *P. calceolariae* have been intercepted on grapes at the New Zealand border 17, 44 and 10 times, respectively. These interceptions were made on grapes from Australia, Chile and the USA, since 1988 (MAFBNZ, 2009).

Given that:

- grapevine is a primary host for *P. maritimus*;
- adults and nymphs, although primarily found on leaves and bark, may be present on the fruit at the time of harvest;
- the size and location of these life stages means they may not be detected at low levels of infestation;

- live adult *P. maritimus*, *P. longispinus* and *P. calceolariae* have been intercepted at New Zealand's border;

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

7.6.2.2 Exposure assessment

Following post-border distribution of imported grapes, any associated 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 (Bartlett (1978).

The primary dispersal stage is the mobile crawler which 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). These results indicate that movement of grape 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). 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. 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). 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. 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 egglaying 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.

7.6.2.3 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. *P. maritimus* females release a pheromone (Beers *et al*, 1993) 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 higher for mealybugs than for solitary 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. *P. maritimus* is established in parts of the world with climates similar to that in many parts of New Zealand. Therefore climate would not be a barrier to establishment in most parts of New Zealand.

Given that:

- individuals of opposite sexes are required for sexual reproduction;
- males are short-lived with limited dispersal ability;
- mate finding is assisted by female production of pheromones, aggregating behaviour, and a clumped distribution;
- hosts are widely distributed and climate is unlikely to be a barrier to establishment in New Zealand;

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

7.6.2.4 Consequence assessment

Economic consequences

Susceptibility to mealybug damage varies by grape variety. It is worse on varieties that produce clusters close to the base of the shoot because the fruit often touches old wood. Mealybugs damage grapes by contaminating clusters with cottony egg sacs, larvae, adults, and honeydew. Often the honeydew is covered with a black sooty mould (University of California, 2008).

Direct damage is caused by the mealybug entering the fruit (Beers *et al*, 1993), but the most significant problem is caused by the ability of *P. maritimus* and other mealybug species to transmit viruses (Spence, 2001). In New Zealand, grapevine leafroll viruses, vectored by *P. longispinus*, and *P. calceolariae*, are having a major impact in reducing vine productivity and wine quality from infected vineyards (P. Lo, pers. comm. 2008). The introduction of viruses not present in New Zealand would be expected to increase these impacts. However, the grape viruses known to be vectored by *P. maritimus* are already present in New Zealand. (This is also the case for *P. longispinus* and *P. calceolariae*).

Indirect consequences of establishment could include an increase in pest control costs and/or disruption of existing control programmes, particularly those based on IPM.

Establishment of this species in New Zealand could cause disruption of access to some markets. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- damage by *P. maritimus* would decrease productivity of grapes and other commercial crops if not controlled;
- transmission by *P. maritimus* of grape viruses already present in New Zealand would decrease productivity of grapes if not controlled;
- controlling *P. maritimus* could increase treatment costs for grape and other crops in New Zealand;
- establishment of *P. maritimus* in New Zealand could cause disruption of access to some markets;

The potential economic consequences are considered to be moderate and therefore non-negligible.

Environmental consequences

P. maritimus is polyphagous. Beever and others (2007) suggested 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 high risk group, particularly polyphagous species. For example, *Pseudococcus longispinus,* which is also introduced and in the same genus as *P. maritimus*, is known to attack a native plant species, *Phormium tenax* (Spiller and Wise, 1982). There are native representatives in New Zealand among some of the genera that are known hosts of *P. maritimus*, for example: *Ipomoea cairica*; *Cyperus ustulatus,* toetoe (endemic); *Rubus cissoides,* bush lawyer (endemic); *Solanum laciniatum*, poroporo. In addition, many exotic plant species in the same families as known hosts of *P. maritimus* 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 displacement of native mealybug species is another possible consequence of establishment.

Given that:

- *P. maritimus* , which is polyphagous, could attack garden and amenity plants that are grown in New Zealand;
- *P. maritimus* could attack some native plant species;
- *P. maritimus* could displace native mealybug species;

The potential environmental consequences are considered to be moderate and therefore non-negligible.

Human health consequences

There are no known human health consequences.

7.6.2.5 Risk estimation

The likelihood of entry is considered to be moderate, the likelihood of exposure is considered to be low, and the likelihood of establishment is considered to be moderate. The potential economic and environmental consequences are considered to be moderate. *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.*

7.6.2.6 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.

There may be other viruses that can be vectored by the three *Pseudococcus* species but there is a lack of information to assess the risk here in relation to this pathway.

7.6.3 Risk management

7.6.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. *P. maritimus* is recorded from Xinjiang in China, indicating a limited distribution. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *P. maritimus*.

Pre-export phytosanitary visual inspection

Mealybugs are small but can be conspicuous due to their bright white colour and powdery appearance. The white cottony mass makes egg sacs easy to see (Beers *et al*, 1993), but early instars may be less conspicuous. If honeydew is present it is often covered with a black sooty mould which should also aid detection. Pre-export phytosanitary visual inspection is considered a viable option when combined with bagging.

Bagging

Individual bagging of fruit is likely to prevent mealybugs from reaching the surface of the fruit. However, bagging will only be a viable risk mitigation option if the bags are in place during the whole growing season, right up until harvest of the grapes. If bagging occurs until harvest it is considered a viable option when combined with phytosanitary visual inspection.

Warm water treatment

The USDA treatment manual gives hot water submergence as a treatment of limes against mealybugs. The treatment has to be performed by submergence to at least 10 centimetres for 20 minutes at 49°C in circulating water (TQAU USDA, 2008). Cooling and/or waxing of the fruit are optional. Mechanical removal with brushes and surfactant baths, for instance with a silicone-based food grade defoamer could aid in the removal of *P. maritimus* before export (Hansen *et al*, 2006). Adding an organosilicone surfactant like Silwet L-77 could enhance this wet treatment. *P. maritimus* crawlers (301 crawlers tested) had 100% mortality when treated with 0.5% Silwet L-77. Even though egg stages were not killed, crawlers that emerged from eggs treated with 0.25% or 0.5% Silwet L-77 died within 24 hours of eclosion (Tipping *et al*, 2003). This indicates adding this surfactant would enhance the efficacy of warm water treatment. Warm water treatment with Silwet is considered a viable option.

Ethyl formate fumigation

Fumigation with ethyl formate in normal air gives good control of *P. maritimus*. The lethal concentration of ethyl formate on table grapes 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). Therefore treatment with an appropriate dose of ethyl formate is considered a viable option.

Methyl bromide fumigation

Australia requires methyl bromide fumigation as a mandatory control for *P. maritimus* (AQIS, 2000). The plant protection and quarantine service of the USDA also advises methyl bromide treatment against Pseudococcidae on grapes. They recommend one of following methyl bromide treatments (TQAU USDA, 2008) (accessed 23/02/2009):

Table 14. Treatment T104-a-2

Temperature (ºC)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
26.67ºC or above	40	32	24
21.11 to 26.11ºC	48	38	29
15.56 to 20.56ºC	64	48	38

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, treatment must kill 99.9968% of the pests in a test of at least 100 000 individual pests. No treatment efficacy level is provided for this specific treatment. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *P. maritimus* or if evidence is provided of the efficacy against *P. maritimus* on table grapes, then methyl bromide fumigation is considered a viable option.

Cold treatment and sulphur dioxide fumigation

Eggs and crawlers may be able to survive cold treatment, since these are the overwintering stages (Beers *et al*, 1993). P. *maritimus* on grapes exposed to low temperatures with a slow release sulphur dioxide pads resulted in 100% mortality after 6 weeks (9567 insects). The insects were tested in plastic cups. A large scale test (3566 insects) with insects on grape bunches resulted in 9% survival after 8 weeks of exposure to cold and SO_2 fumigation, indicating the efficacy of this treatment depends on the methodology used (Yokoyama *et al*, 2001). Although cold treatment combined with sulphur dioxide has a mitigating effect, it is currently not considered a viable single option.

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8 Risk assessment of potential hazards – Lepidoptera (moths and butterflies)

8.1 *Conogethes punctiferalis* – yellow peach moth

Scientific name: *Conogethes punctiferalis* (Guenée, 1854) (Lepidoptera: Pyralidae)
Other relevant scientific names: *Dichocrocis punctiferalis* (Guenée); *Cognogethes punctiferalis* (Guenée); *Astura guttalis* Walker; *Astura punctiferalis* Guenée; *Deiopeia detracta* Walker; *Botys nicippealis* Walker
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

8.1.1 Hazard identification

8.1.1.1 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) and 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 (FAO (2007)). Therefore this report will refer to the species complex although it is unlikely that the Pinaceae-feeding type will be associated with the pathway.

8.1.1.2 New Zealand status

C. punctiferalis is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001) PPIN (2009) (accessed 04/02/2009).

8.1.1.3 Biology

C. punctiferalis is indigenous to China (FAO, 2007). Its eggs are elliptical, about 2 mm, the pupae are brown, 13 mm long and 4 mm wide, while adults are yellow and 12 mm long. 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).

C. punctiferalis has a relatively short life cycle, which takes approximately six weeks to complete in the summer season. It has two to three generations per year (FAO, 2007). In southern China, *C. punctiferalis* was found to have five generations per year (Wang and Cai, 1997). The average lifespan of a first-generation adult female is ten days. Both female and male moths feed on the nectar of the larval host plant and surrounding plants (CPC, 2007).

Two to three days after mating, females start to lay eggs on the surface of fruits, maize ear silk and tassels. Each female lays 20–30 eggs. Eggs hatch in the early morning, 5–8 days after oviposition (FAO, 2007). Newly hatched larvae crawl rapidly on the fruit surface and bore into the fruit within several hours. They remain there until they pupate (CPC, 2007). 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). On grapes, adults lay eggs individually on stalks and larvae bore into stalks or feed on berries (Ram *et al*, 1997). Larvae web the fruit together and feed on them. The larval and pupal periods are 17 and 8 days, respectively (Gour and Sriramulu, 1992). Pupation occurs in feeding galleries (Ram *et al*, 1997).

C. punctiferalis overwinters as full grown larvae (Chai and He, 1987). The larvae overwinter when mature and pupate in mid-winter, in shelters of webbed frass under bark, in stems and fruit (CPC, 2007; Astridge *et al*, 2005).

Most *C. punctiferalis* adults emerge at night, particularly between 20.00 and 22.00 h. They are active until about 05.00 h, when they hide and remain still on the back of host leaves during the day (CPC, 2007).

8.1.1.4 Hosts

C. punctiferalis is highly polyphagous. The fruit-feeding form, which is a borer, has a wide host range, feeding on fruit and crop plants within at least 15 plant families (CPC, 2007; FAO, 2007; Konno *et al*, 1981). Amongst others it feeds on *Pyrus* spp. (pears), *Prunus* spp. (peaches and other stonefruit), *Malus domestica* (apples), *Psidium guajava* (guava), *Castanea* spp. (chestnuts), *Ficus carica* (fig), *Zea mays* (maize), *Ricinus communis* (castor bean), *Helianthus annuus* (sunflower) (CPC, 2007; FAO, 2007). *Vitis vinifera* is a host (AQSIQ, 2007; CPC, 2007).

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. (Konno *et al*, 1981).

8.1.1.5 Plant parts affected

Eggs are laid on the surface of the fruit or stalks. Larvae feed on the surface of, and within, the fruit. Pupae are found inside shelters of webbed frass and may be inside or on the external surface of fruit.

8.1.1.6 Geographic distribution

C. punctiferalis is localised to Asia, Australia and Papua New Guinea. In Asia it is found in, for instance, China (AQSIQ, 2007), India, Indonesia, Japan, Korea, Malaysia, Taiwan, Thailand, Vietnam (CPC, 2007; FAO, 2007; Gour and Sriramulu, 1992; Hang *et al*, 2000; Kang *et al*, 2002).

Within China, *C. 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).

8.1.1.7 Hazard identification conclusion

Conogethes punctiferalis has been recorded on grapevine, and is associated with the grapes. It is present in China and not known to be present in New Zealand. Therefore *C. punctiferalis* is considered to be a potential hazard.

8.1.2 Risk assessment

8.1.2.1 Entry assessment

C. punctiferalis is indigenous to China and has been recorded in a large number of provinces, although it is unknown how prevalent it will be in areas where grapes will be produced for export. Grape is recorded as a minor rather than a major host (CPC, 2007). All life stages of *C. punctiferalis* can be associated with the fruit of grape.

The adults of *C. punctiferalis* have a wingspan of 25 mm and therefore are large enough to be detected during a standard grading and packing process of fruit. They are known to feed on the nectar and fruit of host plants. They are active only at night and hide on the backs of leaves during the day, and are therefore unlikely to be associated with fruit during harvesting. Both female and male moths are highly mobile and are likely to fly away if disturbed.

Eggs, which are 2–2.5 mm long and elliptical in shape, are laid individually on the surface of the fruit or near host fruit or seed. They should be visible to the naked eye but are small enough to escape detection during the standard grading and packing process, especially if laid in the interior of the bunch. In southern China, *C. punctiferalis* was found to have five generations per year and the full-grown larvae overwinter. This indicates eggs could be present at harvest time. The larvae bore into the fruit or shoots where they remain until they pupate. Pathways of introduction of this pest include the transport of infested seeds or fruit (CPC, 2007).

Mature larvae are up to 25 mm long. Although they are large, larvae are internal feeders, feeding on the flesh and the seeds of 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, which are 13mm long and 4mm wide and surrounded by shelters of webbing and frass, sometimes occur on the surface of the fruit. Therefore they should be visible during inspection. However, if this occurs inside the grape bunch they might be hard to detect.

Given that:

- although *C. punctiferalis* is recorded in many provinces in China, its prevalence in grape-growing areas is unknown;

- grape is regarded as a minor host;
- adults are nocturnal and active fliers so are unlikely to be associated with the grape bunches during the harvesting process;
- eggs, larvae and pupae may be associated with the grape bunches at the time of harvest;
- eggs are laid on the fruit surface but may not always be detected during a standard grading and packing process 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 on the grape berries and other damage to the fruit;
- damaged grapes will be discarded during the harvest and packaging process;
- some larvae or pupae may escape detection if present at low levels and are hidden within the grape bunch;
- 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 is considered to be moderate and therefore non-negligible.

8.1.2.2 Exposure assessment

Fresh grapes are likely to be distributed in large quantities throughout New Zealand's city centres as well as provincial regions. The waste material generated (pedicles, peduncle and uneaten grapes) could allow some *C. punctiferalis* larvae to disperse and find a suitable host. *C. punctiferalis* is highly polyphagous and if fruit containing larvae were disposed of in a compost bin or in the environment, there is a chance they might reach a suitable host if present nearby or develop to pupation in the discarded grapes. Eggs need to develop and hatch before the grape bunch becomes unsuitable. Adults that emerge from any pupae are mobile and have a high likelihood of finding a suitable host plant.

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 might spread to nearby plants and complete their development;
- larvae are polyphagous, and acceptable hosts are widely available in modified habitats;
- *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.

8.1.2.3 Establishment assessment

Eggs, larvae and pupae need to develop into adults and then two adults of opposite sex need to locate each other and mate. Since eggs are laid singly this would indicate multiple infested fruit would need to be disposed of in fairly close proximity. The architecture of grape bunches would facilitate this. *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 such as Japan and China where there are areas with cool-temperate climates. *C. punctiferalis* overwinters as a mature larva; therefore it would have the ability to hibernate once conditions become unfavourable, and then resume feeding once conditions are favourable. The lifecycle of the moth and its current distribution, suggest that it would likely 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. In addition, it is generally more frequent in years with continuously wet summers (Astridge *et al*, 2005; Astridge, 2006). This suggests that in New Zealand it would be more suited to warmer, wetter areas such as in the northern regions.

Given that:

- *C. punctiferalis* is sexually reproducing therefore at least one individual of each sex would be required to start a reproducing population;
- although eggs are laid singly, which should decrease the likelihood of individuals of each sex developing to adulthood in the same location, grape architecture increases the change of multiple infested fruit in the same location;
- females employ pheromones to attract males which increases the change 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 moderate and therefore non-negligible.

8.1.2.4 Consequence assessment

Economic consequences

C. punctiferalis infestations result in the stunting, scorching and dropping of fruit. The pest can cause significant damage to stems, fruit and seeds of host plants (FAO, 2007).

In Australia *C. punctiferalis* is seen as a minor and infrequent pest. It is generally more frequent in years with continuously wet summers (Astridge *et al*, 2005). In addition, it has been noted as a major and frequent pest in the wet tropics of north Queensland especially for rambutan (*Nephelium lappacium*) and durian (*Durio* spp.) (Astridge *et al*, 2005; Astridge, 2006). Larvae bore into the fruit of rambutan and can destroy up to 90% of fruit clusters if not controlled (Astridge, 2006). In India, infestation of grapes by *C. punctiferalis* has been reported to result in a 50% reduction in yield (Ram *et al*, 1997). *C. punctiferalis* is an important pest of peaches in southern China and of apples in northern China, and contributes up to 25% of chestnut crop loss (FAO, 2007). 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).

C. punctiferalis appears to be currently confined to Australia and (mostly east) Asia. It is polyphagous with major hosts in the Rosaceae family that are of major economic importance in New Zealand. If the pest were to establish in New Zealand, damage to fruit would directly impact on productivity for various crops. Indirect consequences could include an increase in pest control costs and/or disruption of existing control programmes, particularly those based on IPM. In addition, there could be an impact on market access, including the export of New Zealand pome and stonefruit. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Should the pine-feeding form of *C. punctiferalis* that can feed on certain *Pinus* species such as *P. massoniana* (FAO, 2007; Chai and He, 1987) 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 such as grapes. Therefore it is unlikely to be associated with this pathway.

Given that:

- there could be reduction in productivity for a number of crops in certain regions of New Zealand if damage to fruit by *C. punctiferalis* larvae was not controlled;
- controlling *C. punctiferalis* larvae could increase treatment costs for a number of crops in certain regions of New Zealand;
- there would be reduced market access overseas for some of New Zealand's export crops;

The potential economic consequences are considered to be moderate and therefore non-negligible.

Environmental consequences

C. punctiferalis is highly polyphagous and several of the plant families in which it has hosts (for example, Euphorbiaceae, Myrtaceae, Rutaceae) also have New Zealand native members including endemic species (for example, *Syzygium maire*) and genera (for example, *Lophomyrtus*, *Neomyrtus*). The impact on native flora is uncertain but some impact 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.

Given that:

- *C. punctiferalis*, which is polyphagous, could attack the fruit of garden and amenity plants that are grown in New Zealand;
- *C. punctiferalis* could attack the fruit of some native plant species;

The potential environmental consequences are considered to be moderate and therefore to be non-negligible.

Human health consequences

There are no known human health hazards caused by *C. punctiferalis*.

8.1.2.5 Risk estimation

The likelihood of entry is considered to be moderate, the likelihood of exposure is considered to be moderate, and the likelihood of establishment is considered to be moderate. The potential economic consequences are considered to be moderate, and the potential environmental consequences are considered to be moderate. No human health consequences are expected. *As a result the risk estimate for* Conogethes punctiferalis *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

8.1.2.6 Assessment of uncertainty

There is uncertainty around the prevalence of *C. punctiferalis* in areas of China where grapes are grown, the extent to which the pest is present on grape bunches, 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.

8.1.3 Risk management

8.1.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. *C. punctiferalis* is widespread in China.

Pest-free areas can be a viable option if pest freedom is verified, but with *C. punctiferalis* currently being widespread in China this not considered a viable option.

Combined cold treatment and methyl bromide fumigation treatment

C. punctiferalis overwinters as mature (fifth-instar) larvae. Cold treatment alone is unlikely to mitigate the risk of live larvae entering New Zealand. The USA has two treatment schedules (for different container types) against *C. punctiferalis* on apples from Japan or Korea (TQAU USDA, 2008).

Table 15. Treatment T109-a-1 (plastic bins):

Temperature (ºC)	Exposure Period		
1.11ºC or below	40 days		
Followed by a methyl bromide treatment			
Temperature (ºC)	Rate (g/m³)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
10 ºC or above	48	44	36

Table 16. Treatment T109-a-2 (cardboard cartons):

Temperature (ºC)	Exposure period		
1.11ºC or below	40 days		
Followed by a methyl bromide treatment			
Temperature (ºC)	Rate (g/m³)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
15 ºC or above	38	35	29

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, treatment must kill 99.9968 percent of the pests in a test of at least 100 000 individual pests. No treatment efficacy level is provided for this specific treatment. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *C. punctiferalis* or if evidence is provided of the efficacy against *C. punctiferalis* on table grapes, then cold treatment followed by methyl bromide fumigation is considered a viable option.

Pre-export phytosanitary visual inspection

The egg, larval and pupae stages are associated with fruit. Eggs are white, about 2 mm in diameter and are visible to the naked eye. Larvae are internal feeders; the holes made in fruit by larvae can be quite large and are likely to be easily seen. Larvae web the fruit together and feed on them. The *C. punctiferalis* excretions that cover the fruit surface have a high sugar content and therefore attract other insect pests and diseases that in turn damage fruit. This damage would result in a greater likelihood of detection. Pupae are 13 mm long and should be detectable during a pre-export phytosanitary visual inspection. Pre-export phytosanitary visual inspection is considered a viable option when combined with bagging.

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, bagging will only be a viable risk mitigation option if the bags are in place during the whole growing season, right up until harvest of the grapes. If bagging occurs until harvest it is considered a viable option when combined with phytosanitary visual inspection.

8.2 *Eudocima* spp. – fruit piercing moths

The following *Eudocima* species are grouped together, because the biosecurity risk they present is likely to be similar.

Scientific name: *Eudocima fullonia* (Clerck, 1764) (Lepidoptera: Noctuidae)
Other relevant scientific names: *Othreis fullonia*; *Othreis fullonica*; *Ophideres fullonia*; *Ophideres fullonica*; *Phalaena pomona* Cramer; *Noctua dioscoreae* Fabricius; *Othreis pomona* Hübner; *Ophideres obliteraus* Walker; *Phalaena (Attacus) fullonica* Linnaeus; *Phalaena (Noctua) phalonia* Linnaeus
Common names: fruit piercing moth, fruit-sucking moth, orange-piercing moth

Scientific name: *Eudocima tyrannus* (Guenée) (Lepidoptera: Noctuidae)
Other relevant scientific names: *Adris tyrannus* (Guenée); *Ophideres tyrannus* Guenée; *Othreis tyrannus* (Guenée)
Common names: leaf-like moth, akebia

8.2.1 Hazard identification

8.2.1.1 Taxonomy

Edwards (1996) synonymised the genera *Othreis, Khadira*, *Adris* and *Rhytia* with *Eudocima*. Several taxonomists remain uncertain of this amalgamation, and insist that a thorough generic revision is still required.

8.2.1.2 New Zealand status

E. fullonia and *E. tyrannus* are not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2009) (accessed 05 Feb 2009).

8.2.1.3 Biology

Limited research has been done on *E. tyrannus*. Therefore *E. fullonia* is considered here as a representative for the fruit piercing moths.

Eggs are hemispherical, just over 1 mm in diameter. Eggs are generally laid on the underside of leaves of host plants (CPC, 2007). Eggs are laid in batches of up to 100 (when moth populations are low) or several hundred (when moth populations are high) on the undersides of the host plant leaves (often *Erythrina* spp.), though sometimes on bark or other nearby plants. At about 25˚C eggs will hatch in 3 days (Kumar and Lal, 1983).

There are 5 larval instars, the total duration of which is about 13–22 days. Larvae are between 4 mm (newly hatched) and 60 mm (mature) in length, with variable colouration (Martin-Kessing and Mau, 1993; Fay, 2005) (accessed 05 Feb 2009).

Pupation occurs in a silk cocoon woven between leaves and lasts 16–18 days. After emergence the female usually feeds, mates and then commences egg laying. She may lay up to 750 eggs in her lifetime (Kumar and Lal, 1983).

The adult is large and robust, with a wingspan of 80–100 mm and body approximately 50 mm long (Martin-Kessing and Mau, 1993; Fay, 2005). Females live 27–30 days and males 26–28 days (Kumar and Lal, 1983) and both sexes continue feeding throughout their lifetime. Being nocturnal the moths feed and mate at night, and shelter during the day in dense, undisturbed foliage (Waterhouse and Norris, 1987). In cold marginal areas breeding may cease altogether (CPC, 2007). Unlike most Lepidoptera it is the adult, not the larval stage that is responsible for damage to crops (Fay, 1996). The adult's mouthparts are about 2.5 cm long and designed to pierce thick fruit skins giving access to the juice. The entry site allows bacterial and fungal infections to take hold.

Adults can fly substantial distances. In New Caledonia they regularly move between the mountains and coastal plains (Cochereau, 1977) and in Australia are thought to migrate over long distances.

Fruit is attacked in the adult stage only. In Korea, the adults are associated directly with the fruit and fruit clusters of grape, but only at night (Hanken, 2000 (revised 2002)).

8.2.1.4 Hosts

Adult *E. fullonia* moths are a serious pest of ripening fruits. The adult host plants are different to larval host plants. As with other fruit-piercing moths, plants from the family Menispermaceae are favoured as larval food plants (Fay, 1996). *E. fullonia* particularly favours plants of *Tinospora, Tiliacora, Triclisia* and *Stephania* genera (Waterhouse and Norris, 1987; Cochereau, 1977). In the Pacific, larvae feed on plants in the genus *Erythrina* (which is in the family Fabaceae but has alkaloids similar to those in some species of Menispermaceae (Fay, 1996)), as well as the creeper *Stephania forsteri* (Menispermaceae) (Cochereau, 1977).

The adults of *E. fullonia* are known to attack more than 40 different types of fruit (Martin-Kessing and Mau, 1993; Fay, 2005) including: *Vitis vinifera* (grape) (Hanken 2000 (revised 2002)), *Actinidia chinensis* (kiwifruit), *Carica papaya* (papaw), *Citrus limon* (lemon), *Citrus maxima* (pummelo), *Citrus reticulata* (mandarin), *Citrus sinensis* (navel orange), *Erythrina subumbrans* (December tree), *Lycopersicon esculentum* (tomato), *Prunus americana* (apricot), *Prunus domestica* (plum), *Prunus persica* (peach) (Martin-Kessing and Mau, 1993; Fay, 2005; CPC, 2007; Waterhouse and Norris, 1987).

For *E. tyrannus*, rearing experiments in Nepal and Thailand found that larvae would accept *Berberis* and *Mahonia* (Berberidaceae) as well as *Holboellia* (Lardizabalaceae) and, to a lesser extent, *Cocculus*, *Sinomenium* and *Tinospora* in the Menispermaceae (Banziger (1987) cited in Holloway 2009). These families are all in the order Ranunculales.

8.2.1.5 Plant parts affected

Ripe fruit seems to be preferred, but greener fruit is often attacked when moth populations are large. Adults may also feed on some over-ripe or damaged fruit. The importance of

E. fullonia to a host crop frequently depends on harvest practice, with early picking limiting the moth's impact (CPC, 2007).

8.2.1.6 Geographic distribution

E. fullonia is native to the Indo-Malay region and is widespread throughout Asia, Africa and the Pacific basin (CPC, 2007; Waterhouse and Norris, 1987). It is present in China (AQSIQ, 2007; Huang and Geng, 1997; Park *et al*, 1988; CABI, 2001).

E. fullonia is an occasional vagrant in New Zealand, recorded under its synonym *Othreis fullonia* (Dugdale, 1988), that is thought to be blown in from Australia on the prevailing westerly winds. *E. fullonia* is an occasional immigrant that has not established in New Zealand (J. Dugdale, pers. comm. 2007).

E. tyrannus is a Palaearctic species (Brou, 2006). It has been recorded in China (AQSIQ, 2007; Ades and Kendrick, 2004), Thailand (Banziger, 1987), Korea (Kim and Lee, 1986; Hanken, 2000 (revised 2002)) and Japan (Fujimura, 1972). The type specimen is from India (Zaspel and Branham, 2008) and it has been recorded in Alaska (Kruse, 2002 (cited in Brou, 2006) and the Russian Far East (Zaspel and Branham, 2008).

8.2.1.7 Hazard identification conclusion

Eudocima fullonia and *E. tyrannus* have been recorded on grapevine, and are associated with the fruit. They are present in China. They are not known to be established in New Zealand, and are considered to be a potential hazard.

8.2.2 Risk assessment

8.2.2.1 Entry assessment

Only the adults of these species are associated with fruit. Larvae require entirely different host species. Being nocturnal the moths feed at night and shelter during the day in dense, undisturbed foliage (Waterhouse and Norris, 1987). It is highly unlikely that adults would be associated with the fruit during harvesting, or that they would remain with the fruit once harvested (Hanken, 2000 (revised 2002)).

Given that:

- only the adults are associated with the fruit of grapevine;
- the adults are highly mobile, being strong fliers;
- the adults are nocturnal and therefore unlikely to be associated with fruit while it is being harvested;
- the adults are likely to be disturbed and fly away if present on fruit at harvest;
- the adults are large (for example, *E. fullonia* has a wingspan of 80–100 mm) and therefore readily visible;

The likelihood of entry is considered to be negligible.

8.2.2.2 Risk estimation

The likelihood of *Eudocima fullonia* and *E. tyrannus* entering New Zealand with grape bunches from China is negligible. *As a result the risk estimate for* Eudocima fullonia *and* E. tyrannus *is negligible and they are not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

8.2.2.3 Assessment of uncertainty

There is little information on *Eudocima tyrannus* and it is assumed the biology has similarities to that of *E. fullonia*. Certainly this is the case for the most critical information in this risk assessment: the adults of both species will pierce and feed on fruit of plants unrelated to the larval host plants which tend to be in the family Menispermaceae.

8.3 *Eupoecilia ambiguella* – grapevine moth

Scientific name: *Eupoecilia ambiguella* (Hübner) (Lepidoptera: Tortricidae)
Other relevant scientific names: *Clysia ambiguella* Hübner; *Clysiana ambiguella* Hübner; *Tinea ambiguella* Hübner; *Conchylis ambiguella*
Common names: grapevine moth, European grape berry moth, grape bud moth, vine moth

8.3.1 Hazard identification

8.3.1.1 New Zealand status

Eupoecilia ambiguella is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2009) (accessed 23/02/2009).

8.3.1.2 Biology

Moths emerging from overwintered pupae appear at different intervals depending on the region and weather conditions. There are two to three generations per year (AgroAtlas, 2008). The second flight takes place 2 to 2.5 months after the first (HYPPZ, 2008).

The eggs are slightly elliptical, measuring 0.8 mm in length. Females lay eggs one by one. The eggs are deposited in the evening on the flower buds or, for the second generation, on the immature fruits of grapes (HYPPZ, 2008). The duration of egg development is 13 days at 15°C, 6–7 days at 19–25°C (AgroAtlas, 2008).

Larvae grow up to around 14 mm in length; they are initially light gray, then later dark red or pinkish (AgroAtlas, 2008). The young caterpillar moves about on the plant for a few minutes then, to feed it slips between two or three flower buds which it unites with silk threads, forming a web. It thickens the web gradually. The second generation larvae live on unripe fruits, causing them to rot (HYPPZ, 2008). Development of first generation larvae lasts 15–25 days (AgroAtlas, 2008). First generation larvae eat flower buds, gnaw anthophores, and eat buds and flowers, densely covering them with a web. If an inflorescence has 3–4 webs, it will be completely destroyed (AgroAtlas, 2008). Second generation larvae gnaw out round holes and penetrate the berries, eating away pulp and unripe seeds before they harden. One larva is able to damage 9–12 berries on average. The residues of damaged berries dry up, like raisins, growing mouldy in rainy weather (AgroAtlas, 2008). At larval populations of more than 0.5 larvae per cluster there is an aggregated distribution (Pavan *et al*, 1998).

The first-generation caterpillar pupates in leaf folds; those of second generation in a greyish or brownish cocoon spun under the old bark of the vine-stock or in cracks in stake-posts. The pupal stage lasts 14 days (HYPPZ, 2008).

Adults have a 14 to 18 mm wingspan (AgroAtlas, 2008). The moth flies from dusk to dawn. There is a threshold for mating of 11°C, and an optimum between 19°C and 22°C (Schmieder and Schruft, 1987). Oviposition takes place in humid sheltered sites (HYPPZ, 2008). Females lay up to 100 eggs (AgroAtlas, 2008). The egg-laying period for the overwintered females usually coincides with the inflorescence status of grapes (AgroAtlas, 2008).

Diapausing pupae over-winter in dense cocoons under exfoliating bark, in crevices and in cracks of stalks (AgroAtlas, 2008). At 11–12°C over-wintered pupae need 40–45 days and a sum of about 180 day degrees for their development. On average, development of the summer generation continues for 47 days. At the end of August larvae leave their feeding places and spin cocoons, where they pupate and over-winter (AgroAtlas, 2008). The lower developmental threshold has been determined as about 7°C (AgroAtlas, 2008). Development is strongly influenced by air humidity; adult fecundity sharply decreases in low relative humidity (30–40%) and at temperatures of 30–32°C the majority of eggs are not viable. Levels of 70–90% RH and air temperature 18–25°C are the most favourable for insect development (AgroAtlas, 2008).

8.3.1.3 Hosts

Major hosts are *Prunus domestica* (plum), *Ribes nigrum* (blackcurrant), *Vitis vinifera* (grapevine (for example, Pavan *et al*, 1998). *Prunus salicina* (Japanese plum) is a minor host (CPC, 2007) (accessed 23/02/2009). Larvae are polyphages, damaging fruits of buckthorn, viburnum (*Viburnum*), ivy, lilac, honeysuckle, Cornelian cherries, maple, virginia creeper (*Ampelopsis*), currant, blackthorn (*Prunus spinos*a), yellow bedstraw (*Galium*), privet (*Ligustrum*), tin-laurel (*Viburnum tinus*), ash (*Fraxinus*) and other arboreous and fruticose plants (AgroAtlas, 2008; HYPPZ, 2008).

8.3.1.4 Plant parts affected

Flower buds, berries.

8.3.1.5 Geographic distribution

E. ambiguella is widespread in Europe, and is also known in Brazil and Asia. In Asia it is found, among others, in China (Zhang and Li, 2008), Korea, and Japan (AgroAtlas, 2008; CPC, 2007).

8.3.1.6 Hazard identification conclusion

Eupoecilia ambiguella has been recorded on grapevine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *E. ambiguella* is considered to be a potential hazard.

8.3.2 Risk assessment

8.3.2.1 Entry assessment

The eggs are laid on flower buds or, for the second generation, on the fruits. Second generation larvae feed on unripe fruits, causing them to rot (HYPPZ, 2008). The eggs and larval stages are difficult to see due to their colour and size (Marcelin, 1985) and because larvae bore into the grapes (Marcelin, 1985). The egg stage lasts only a few days, and so eggs are unlikely to be present on the fruit at harvest in September/October. First-generation larvae pupate in leaf folds; those of second generation in a greyish or brownish cocoon spun under the old bark of the vine-stock or in cracks in stake-posts at the end of August. Therefore most larvae are likely to have left the fruit by the time of harvest. Remaining larvae may be detected during the harvest and packing process by the presence of entry holes and the residues of damaged grapes. The adult moth is active from dusk to dawn and is unlikely to be present on grape bunches, or to stay on during the harvesting process.

Given that:

- adults are nocturnal and active fliers so are unlikely to be associated with the grape bunches during the harvesting process;
- larvae are the only other stage that might be associated with the grape bunches at the time of harvest;
- most larvae will have left the fruit to pupate at the time of harvest;
- damaged grapes will be discarded during the harvest and packing process
- remaining larvae may be detected during the harvest and packing process by the presence of entry holes on the grape berries and other damage to the fruit;

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

8.3.2.2 Exposure assessment

Pedicels, peduncle and uneaten berries are discarded, mainly in garbage bags, compost heaps or directly into the environment. If uneaten berries are thrown in compost heaps or the environment, larvae might be able to spread to plants in the vicinity and complete their development. The larvae can feed on a range of hosts, some of which, for example ivy, are widely distributed throughout modified habitats in New Zealand.

Given that:

- uneaten fruit that contains larvae may be discarded in compost heaps or the environment
- larvae might spread to nearby plants and complete their development;
- larvae are polyphagous, and acceptable hosts are widely available in modified habitats;

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

8.3.2.3 Establishment assessment

Individuals of the opposite sex are required for a population to establish. This means that multiple larvae would need to complete their development. In Europe, *E. ambiguella* is present from Finland and Norway down to Portugal and Spain. The lower threshold of development is about 7°C. Development is strongly influenced by air humidity; adult fecundity sharply decreases in low relative humidity (30–40%). The minimum threshold for mating is 11°C. There is no obvious climatological reason why this moth could not become established in New Zealand. Grapevine is one of its major hosts and is grown throughout the country. Other acceptable hosts such as plums, blackcurrant, ivy and privet are found widely in New Zealand's modified habitats.

Given that:

- reproduction is sexual so at least one individual of each sex is required to start a reproducing population;
- larvae are polyphagous, feeding on buds and fruits of grapes, plums and other introduced species that appear in New Zealand's modified environments;
- the known distribution of *E. ambiguella* suggests that climate would not be a barrier to establishment in New Zealand;

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

8.3.2.4 Consequence assessment

Economic consequences

E. ambiguella causes damage to grapes. One larva of the first generation can destroy up to 30 buds and one larva of the second generation can destroy up to 17 grape berries (AgroAtlas, 2008). Damage to grapes can be considerable. The presence of larvae, webs and rotten fruits downgrades the crop. The development of moulds renders wine-making difficult (HYPPZ, 2008). In Italy, the economic threshold for the application of pest control measures in the vineyard is 20% of bunches attacked by at least one larva (Valli, 1975).

Given that:

- damage by *E. ambiguella* larvae would decrease grapevine productivity if not controlled;
- controlling *E. ambiguella* could increase pest control costs in vineyards in New Zealand;

The potential economic consequences are considered to be moderate and therefore non-negligible.

Environmental consequences

The larvae feed on the fruit of a range of hosts, some of which are amenity species in New Zealand.

Given that:

- the larvae might attack the fruit of some amenity species in New Zealand;

The potential environmental consequences are considered to be low and therefore non-negligible.

Human health consequences

There are no known human health consequences.

8.3.2.5 Risk estimation

The likelihood of entry is considered to be very 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 potential environmental consequences are considered to be low. *As a result the risk estimate for* Eupoecilia ambiguella *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

8.3.2.6 Assessment of uncertainty

There is a lack of information about the distribution of this organism throughout China. Moreover, the effects of current harvest methods and transport on its presence in harvested table grapes are uncertain.

8.3.3 Risk management

8.3.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or ISPM 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. *E. ambiguella* is assumed to be widespread in China. Pest-free areas can be a viable option if pest freedom is verified, but with *E. ambiguella* currently assumed to be widespread in China this not considered a viable option.

Bagging

Individual bagging of fruit may protect it from infestation by *E. ambiguella*. However, bagging will only be a viable risk mitigation option if the bags are in place during the whole growing season, right up until harvest of the grapes. If bagging occurs until harvest it is considered a viable option when combined with phytosanitary visual inspection.

Pre-export phytosanitary visual inspection

The larvae bore into the grape berries, making it difficult to detect an infection. The presence of a fungal infection could indicate the presence of this pest. Pre-export phytosanitary visual inspection is considered a viable option when combined with bagging.

Methyl bromide fumigation

Control measures effective against *Lobesia botrana* (Lepidoptera: Tortricidae) are considered to be effective against *E. ambiguella* (AgroAtlas, 2008). The Plant Protection and Quarantine Department of the USDA currently recommends one of following methyl bromide treatments against *L. botrana* on grapes (TQAU USDA, 2008) (accessed 23/02/2009):

Table 17. Treatment T101-h-2

Temperature (ºC)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
26.67ºC or above	24	19	14
21.11 to 26.11ºC	32	26	19
15.56 to 20.56ºC	40	32	24
10.00 to 15.00ºC	48	38	29
4.44 to 9.44ºC	64	48	38

Table 18. Treatment T101-h-2-1

Temperature (ºC)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:					
		0.5 hr	2 hrs	2.5 hrs	3 hrs	3.5 hrs	4 hrs
21.11 ºC or above	32	26	22	22	–	21	–
18.33 to 20.56ºC	32	26	22	22	–	–	19

Alternatively, the treatments as described against *Bactrocera dorsalis* will be equally as effective (TQAU USDA, 2008).

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, treatment must kill 99.9968 percent of the pests in a test of at least 100 000 individual pests. No treatment efficacy level is provided for this specific treatment. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *E. ambiguella* or if evidence is provided of the efficacy against *E. ambiguella* on table grapes, then methyl bromide fumigation is considered a viable option.

Cold treatment and sulphur dioxide

The lower threshold of development is about 7°C. Development is strongly influenced by air humidity; adult fecundity sharply decreases in low relative humidity (30–40%). The larva is the stage with low likelihood of entry, and this is not the stage that goes into diapause. These results indicate *E. ambiguella* is sensitive to cold treatment, although the effectiveness of this treatment is uncertain. Cold tolerance in the Tortricidae is highly variable and complicated, partly because some species diapause (Pryke and Pringle, 2008). For instance, the most tolerant fourth instar of *Grapholita prunivora* has a LT_{99} of 236 days at 2°C, in a test of 1078 individuals (Neven, 2004). The most cold-tolerant second instar of *Platynota stultana* showed 0.2% survival to adulthood after 6 weeks at 0–1°C (2400–5400 larvae tested) (Yokoyama and Miller, 2000). An 8-week storage period at 0.4–1.7°C combined with a slow release sulphur dioxide pad resulted in 100% mortality of 23256 second instar *P. stultana* (placed in cups among table grapes) (Yokoyama *et al*, 2001). Cold treatment combined with sulphur dioxide treatment is effective against a range of pests (Yokoyama *et al*, 2001) and might be effective against *E. ambiguella*. Until the efficacy against *E. ambiguella* is proven in a large-scale commercial trial, cold treatment combined with SO_2 fumigation is not considered a viable option.

8.4 *Hyphantria cunea* – fall webworm

Scientific name: *Hyphantria cunea* Drury, 1770 (Lepidoptera: Arctiidae)
Other relevant scientific names: *Hyphantria textor* (Harris); *Phalaena (Bombyx) cunea* Drury; *Phalaena punctatissima* Smith; *Cycnia cunea* Hubner; *Spilosoma cunea* (Drury); *Euproctis textor* (Harris); *Hyphantria punctata* Fitch
Common names: fall webworm, mulberry moth, blackheaded webworm, redheaded webworm, American white moth

8.4.1 Hazard identification

8.4.1.1 New Zealand status

Hyphantria cunea is not known to be currently present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), Scott and Emberson (1999). It has been recorded in New Zealand five times over the period 2003–2005 (PPIN, 2008) and did establish briefly in Auckland (Kean, 2003). In 2006, MAF declared *H. cunea* to be eradicated from New Zealand.

8.4.1.2 Biology

Hyphantria cunea is a serious defoliator of fruit and forest trees. It 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).

In the USA, there are two races of *Hyphantria cunea*: those with larvae with yellow-white bodies and red heads and those with larvae with brown bodies and black heads (CPC, 2007) (accessed 11/02/2009). There are differences in the morphology, behaviour and development time of the two strains, however they do interbreed and produce viable progeny (Ito and Warren, 1973; Warren and Tadic, 1970).

The eggs of *H. cunea* are globe shaped and about 0.6 mm in diameter (Warren and Tadic, 1970). They are laid on the underside of leaves of host plants (Johnson and Lyon, 1988). The number of eggs can range from 300 to 1300. The egg stages ranges from 5 to 23 days (Warren and Tadic, 1970). Larvae feed close to where they hatch, within a communal web. 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. Later instars are more likely to feed away from the nest. The number of instars is variable, but is most typically six or seven (Warren and Tadic, 1970). Larvae show a distinct preference for sun leaves rather than shade leaves. Fully grown caterpillars are 30–35 mm long with 10–12 mm long hairs. When the caterpillars reach full size they actively seek suitable pupations sites in protected areas including soil, leaf litter, bark crevices and inanimate objects (Warren and Tadic, 1970). In China, pupation is recorded in debris or underground (Zhang *et al*, 1996). Depending on the conditions during larval development the pupae will either be diapausing or non-diapausing (Cornell University, 2001; MAF Biosecurity New Zealand, 2008). Both diapausing and non-diapausing pupae can survive -15°C for 24 hours and -5°C for 2 weeks (Li *et al*, 2001). Fall webworm overwinters as a diapausing pupa which can survive for months (Warren and Tadic, 1970). Adults range from 11–15 mm long, with females slightly larger than males.

H. cunea has a variable number of generations per year, depending on climate and photoperiod (Gomi, 1997; Kean, 2003). For instance in Japan it has two to three generations, while in Canada it has only one (Gomi and Takeda, 1996; Morris, 1963). Modelling suggests it would have two generations per year if established in Auckland (Kean, 2003). Adults emerge from diapausing pupae in spring or early summer (Warren and Tadic, 1970). Fall webworm adults are nocturnal, emerging in the early evening (Hirai, 1972). Females fly to host plants generally prior to midnight (Suzuki and Kunimi, 1981). The maximum reported survival time for females is around two weeks, and for males less than one week (Warren and Tadic, 1970). Adults do not feed as they have a reduced proboscis (Gomi, 2000). The main natural dispersal stage is as adults (MAFBNZ, 2008).

8.4.1.3 Hosts

H. cunea attacks a wide range of forest and fruit trees, but also herbaceous plants and some conifers. It has a very large host range (CPC, 2007; Warren and Tadic, 1970).

It attacks, among others: *Acer negundo* (box elder), *Diospyros virginiana* (persimmon), *Juglans nigra* (black walnut), *Liquidamber styraciflua* (liquidamber), *Malus domestica* (apple), *Morus alba*, *Prunus avium* (sweet cherry), *Prunus cerasus* (sour cherry), *Prunus domestica* (plum), *Pyrus communis* (European pear), *Juglans regia* (walnut), *Pinus densiflora* (Japanese umbrella pine). Grapevine is a minor host (CPC, 2007).

8.4.1.4 Plant parts affected

Feeding by *Hyphantria cunea* larvae appears to be confined to the leaves of host plants. However, Brunner and Zack (1993) (accessed 12/02/2009) state that if fruit is enclosed in the webs they will feed on it.

8.4.1.5 Geographic distribution

H. cunea is native to North America and since 1940 it has spread to more than 15 European countries as well as Japan, Korea and China, where it has become a significant pest (CPC, 2007; Warren and Tadic, 1970). *H. cunea* has been reported to be eradicated from Denmark, Germany, Lithuania (CPC, 2007).

8.4.1.6 Hazard identification conclusion

Hyphantria cunea has been recorded on grapevine, and is associated with fruit. It is present in China and is not known to be present in New Zealand. Therefore, *H. cunea* is considered to be a potential hazard.

8.4.2 Risk assessment

8.4.2.1 Entry assessment

H. cunea are serious defoliators of trees. Eggs are laid on the underside of leaves of host plants (Johnson and Lyon, 1988). Feeding by *H. cunea* larvae appears to be confined to the leaves of host plants; however, Brunner and Zack (1993) state that if fruit is enclosed in the webs they will feed on it. Fully grown larvae are 30–35mm long, with hairs 10–12mm long and are highly visible and fruit encased in webs is unlikely to be harvested. Larvae actively seek suitable pupations sites in protected areas such as soil, leaf litter, bark crevices and inanimate objects. Fall webworm adults are nocturnal, emerging in the early evening (Hirai, 1972). Adults do not feed as they have a reduced proboscis (Gomi, 2000). They would therefore not be associated with harvested 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.

Given that:

- the various life stages of *H. cunea* are not normally associated with fruit;
- eggs and larvae live inside webs that are highly visible;
- any late instar larvae that have wandered from webs would be highly visible;

The likelihood of entry is considered to be negligible.

8.4.2.2 Risk estimation

The likelihood of entry of *H. cunea* on table grapes from China is considered to be negligible. *As a result the risk estimate for* Hyphantria cunea *is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

8.4.2.3 Assessment of uncertainty

There is uncertainty about the presence of *Hyphantria cunea* on grapes in China.

8.5 *Mamestra brassicae* – cabbage moth

Scientific name: *Mamestra brassicae* (Linnaeus, 1758) (Lepidoptera: Noctuidae)
Other relevant scientific names: *Phalaena omicron* Geoffroy; *Noctua albidilinea* Haworth; *Barathra brassicae* (Linnaeus); *Hypobarathra unicolor* Marumo; *Phalaena Noctua brassicae* Linnaeus
Common names: cabbage moth, cabbage armyworm, cabbage army moth

8.5.1 Hazard identification

8.5.1.1 New Zealand status

M. brassicae is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2009) (accessed 24/02/2009).

8.5.1.2 Biology

M. brassicae is a leaf defoliator, which can lead to all but the veins being eaten (Hobaus, 1987). The eggs are laid in regular batches of up to 70–80, mainly on the undersides of leaves (biology is according to CPC (2007) (accessed 24/02/2009), unless stated otherwise). The eggs are about 0.7 mm in length (Basar and Ugur, 1995). The eggs normally hatch in 6–14 days, and the larvae immediately start to feed on the leaves.

There are six larval instars. First and second-instar larvae are about 3–10 mm long, while full-grown larvae are about 50 mm long. In the first three or four instars, the larvae feed mainly on the external leaves (Hobaus, 1987). The first instars stay clustered (HYPPZ, 2008). Older larvae can also feed on ripening grapes (Voigt, 1974). The damage to grapes is much smaller than to leaves; the larvae usually only eat a few berries of a cluster (Hobaus, 1987), but damage was often followed by heavy infection with *Botrytis cinerea* (Voigt, 1974). From the fifth instar they display a negative phototaxis and move into the heart of the plants. Nearly full-grown larvae are often concealed in the soil during daytime or in the shady parts of the grapevine and enter the plants to feed at night. Full-grown larvae can also hide in grape bunches but do not damage them (Voigt, 1974). Larval development normally takes 4–7 weeks and the larvae are very mobile (Hobaus, 1987).

Mature larvae leave the plants to pupate in thin cocoons in the soil (Voigt, 1974) at a depth of about 3–5 cm. The pupae are elongate and 17–22 mm long. The adult moths emerge from pupae in the soil. The adult moths have a wingspan of 38 mm (Basar and Ugur, 1995). The species is nocturnal in habit (Hobaus, 1987).

Mean developmental times were found to be 7.6–29.5 days for eggs, 39.8–98.3 days for larvae (temperature range 10.5–18.5°C), 18.2–96.9 days for pupae, and 3.3–9.4 days for the preoviposition period (temperature range 10–23.0° C). Egg to adult development takes about 6 weeks at 25°C, 9 weeks at 20°C and 15 weeks at 15°C. Diapause is facultative and occurs in the pupal stage. In laboratory experiments, larval mortality increased with decreasing temperature within the range 18.0–10.5°C. The lower developmental thresholds and thermal requirements were 8.6°C and 75 degree-days for eggs, 5.4°C and 496 degree-days for the total larval period, 7.2°C and 304 degree-days for pupae, and 5.0°C and 56 degree-days for the preovipositional period, respectively. Pupal mortality was low at all temperatures. The survival of eggs and larvae was highest at 18°C, whereas mortality was 100% at 8.5°C (Johansen, 1997). Depending on the climate, *M. brassicae* develops one to three generations per year. The first generation is thought to develop outside the grapevines (Voigt, 1974).

8.5.1.3 Hosts

Although they prefer *Brassica* crops, *M. brassicae* larvae are extremely polyphagous. Major hosts are *Allium* (onions, garlic, leek, etc.), *Beta vulgaris* var. *saccharifera* (sugarbeet), *Brassica oleracea* (cabbages, cauliflowers, Brussels sprouts, broccoli), *Lactuca sativa* (lettuce), *Solanum tuberosum* (potato), *Zea mays* (maize)

Some minor hosts are *Capsicum* (peppers), *Fragaria* (strawberry), *Linum usitatissimum* (flax), *Malus domestica* (apple), *Prunus persica (*peach), *Rosa* (roses), *Vitis vinifera* (grapevine) (CPC, 2007; Voigt, 1974).

8.5.1.4 Plant parts affected

Fruits/pods, growing points, inflorescence, leaves, roots, stems and whole plant

8.5.1.5 Geographic distribution

Spread throughout Europe, in Libya and in Asia. In Asia it is found, among others, in China, India, Japan, Korea and Pakistan (CPC, 2007; Hobaus, 1987; HYPPZ, 2008; Voigt, 1974; Zheng *et al*, 2000; Hu, 1987).

8.5.1.6 Hazard identification conclusion

Mamestra brassicae has been recorded on grapevine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *M. brassicae* is considered to be a potential hazard.

8.5.2 Risk assessment

8.5.2.1 Entry assessment

Grape is only a minor host and the first generation of *M. brassicae* is thought to develop outside the grapevines (Voigt, 1974). The eggs are laid on the undersides of leaves and are therefore not considered to be associated with the commodity. The adult moths emerge from pupae in the soil, are nocturnal and easily disturbed. Therefore, pupae and adults are considered not to be associated with the commodity. The larvae feed mainly on the external leaves. Older larvae can feed on grapes, but usually only eat a few berries of a cluster (Hobaus, 1987). The damage to the berries was followed by heavy infection with *Botrytis cinerea* (Voigt, 1974) which would be likely to be detected and discarded during harvest. Nearly full-grown larvae are often concealed in the soil during daytime or in the shady parts of the grapevine and enter the plants to feed at night (Voigt, 1974). Full-grown larvae can also hide in grape bunches but do not harm them (Voigt, 1974). Full-grown larvae are about 4 cm long. A standard inspection of the grapes before packing, as is done with the grapes in China, would be expected to find any larvae present. Moreover, the larvae are highly mobile and not expected to stay with the grapes during the whole harvest and packing process.

Given that:

- older larvae are the only life stage of *M. brassicae* likely to be associated with the commodity while it is being harvested;
- older larvae are highly mobile and unlikely to stay with the grapes during handling;
- older larvae are large and readily detectable upon standard grading and packing process of the grape bunch before packing;

The likelihood of entry is considered to be negligible.

8.5.2.2 Risk estimation

The likelihood of entry of *M. brassicae* on table grapes from China is considered to be negligible. *As a result the risk estimate for* M. brassicae *is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

8.5.2.3 Assessment of uncertainty

Limited information is available on the frequency at which this moth infests grape berries in China. Moreover, the biology of this moth on *Vitis vinifera* has not been researched intensively.

8.6 *Nippoptilia vitis* – grape plume moth

Scientific name: *Nippoptilia vitis* Sasaki, 1913 (Lepidoptera: Pterophoridae)
Other relevant scientific names: *Stenoptilia vitis* Sasaki (Anonymous 1935)
Common names: grape plume moth (Zheng *et al*, 1993 [from CAB Abstracts])

8.6.1 Hazard identification

8.6.1.1 Taxonomy

Nippoptilia vitis Sasaki, 1913 is the provisionally accepted name (Beccaloni *et al*, 2005). This species also appears in the literature as *Stenoptilia vitis* Sasaki (Anonymous, 1935). Hori (1933) [from CAB Abstracts] gives *Oxyptilus mycites* Meyr. and *O. formosanus* Mats. as synonyms for *N. vitis*. However, *Nippoptilia formosanus* Matsumura, 1931 and *Nippoptilia mycites* Meyrick, 1914 are listed in Beccaloni and others (2005) as separate species in the same genus as *N. vitis*. The authors include these three species in a list of six provisionally accepted species in the genus *Nippotilia*.

8.6.1.2 New Zealand status

Nippoptilia vitis is not known to be present in New Zealand. Not recorded by: Dugdale (1988), Hoare (2001), PPIN (2009) (accessed 4 March 2009).

8.6.1.3 Biology

In the Jilin Province, China, *N. vitis* is a pest of grapes grown in hilly and extensively farmed areas. Larvae damage leaves, stems, and fruit (APHIS-USDA, 2002, original sources not available; Federal Register, 2004). Damage to fruit can result in severe fruit fall and partially abnormal fruit. Two generations are completed annually, and the second generation overwinters as adults (Zheng *et al*, 1993, in CAB Abstracts).

There is little information available/readily accessible for this species in English. The following are general comments relating to Pterophoridae, or plume moths. Adults are active at twilight or nocturnal. In most species, the wings are divided into narrow feathery lobes. Most adults rest with their wings rolled (hind wing inside the forewing) and held out from the sides of the body in a characteristic T-shape, often resembling a piece of dried grass. Eggs are markedly flattened, and smooth or minutely pitted. Some larvae are borers in roots, stems, fruits, seeds or seed-pods. Other larvae are external leaf-browser but may conceal themselves by rolling leaves or creating ‘nests’ with webbing. Pupae can be exposed, with no cocoon, or concealed; subterranean, or on the surface of the ground, or above the ground (Watson and Dallwitz, 2003; Herbison-Evans *et al*, 2009).

8.6.1.4 Hosts

Species in the Family Vitaceae, including *Vitis vinifera* L. and other *Vitis* spp. (Zheng *et al*, 1993; Anonymous, 1935; Hori 1933 [all from CAB Abstracts]; APHIS-USDA 2002 [original sources not available]; NHM – Caterpillar Hostplants Database).

8.6.1.5 Plant parts affected

Larvae damage leaves and stems, and fruit (APHIS-USDA 2002, original sources not available). Damage to fruit can result in severe fruit fall and partially abnormal fruit (Zheng *et al*, 1993 [from CAB Abstracts]).

8.6.1.6 Geographic distribution

Nippoptilia vitis has been recorded from the following countries:

China – described as a new pest of grapes in Jilin Province (Zheng *et al*, 1993; Wu and Li (1998) refer to an investigation of *N. vitis* on grapevines during 1994–96 in Guizhou, China)

Japan – including Fukuoka Prefecture, Kyushu (Anonymous, 1935; Hori, 1935 [both from CAB Abstracts])

Korea [APHIS-USDA (2002), original sources unavailable: Clausen, 1931; Hong, 1995; Shiraki, 1952; Takahashi, 1915)]

8.6.1.7 Hazard identification conclusion

Nippoptilia vitis is present in China. It is not known to be in New Zealand. It is associated with grapevine and infests table grapes, and is therefore classed as potential hazard in this analysis.

8.6.2 Risk assessment

8.6.2.1 Entry assessment

It is assumed that *N. vitis* is reasonably prevalent in China because it has been recorded as a newly emerged pest of grapes by Zheng and others (1993). The larvae feed on and damage the fruit of grapes. If typical of Pterophorids then they are likely to either bore into the fruit or conceal themselves around or within the fruit cluster while feeding. If an infestation has been heavy and therefore damaging then the partially abnormal appearance of the bunches, and possibly other signs such as frass or webbing, mean that the bunch is likely to be rejected at the time of harvest or during post-harvest inspection. If the infestation is light, larvae may be detected directly or by signs such as frass or damage, unless well concealed within the fruit cluster. It is unknown if the eggs are laid on or close to the fruit or how visible they are. It is also unknown if the pupae are normally associated with the fruit, but if so they are likely to be detected by the standard grading and packing process unless well concealed in the fruit cluster. Adults are nocturnal or crepuscular and, therefore, are unlikely to be associated with fruit while it is harvested, or to fly away if disturbed. Requirements for development are unknown, however, should pupae or adults develop in transit then they are likely to be detected due to their size and probable confinement within the plastic packaging of individual grape bunches.

Given that:

- adults are not likely to be associated with the commodity during harvest;

- larvae are likely to be detected directly or by signs such as frass, webbing or damage;
- larvae may escape detection if the infestation is very light, and they are well-concealed within the fruit cluster;
- it is unknown if eggs or pupae are normally associated with the fruit, however, pupae are likely to be detected upon the standard grading and packing process unless well-concealed;
- any life stages that develop within the commodity after harvest are likely to be detected later, especially pupae and adults;

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

8.6.2.2 Exposure assessment

Following post-border distribution of imported grapes, any associated *N. vitis* need to disperse and locate suitable hosts. It is assumed that larvae don't disperse far and that adult moths are the usual dispersal stage for this species. As larvae feed on the fruit of the grape the moth could develop through to pupa and then adult after harvest whilst remaining within the bag that the bunch is packed in. The physical substrate requirements for pupation are not known, however, pterophorids often remain associated with the host plant. Adults would have the opportunity to disperse once the grapes have been removed from the bag by the consumer. Pedicels, peduncle and uneaten berries will be thrown away, especially if they appear damaged. If these are thrown in compost heaps then larvae may have the opportunity to finish development through to adult and disperse. Although the host range of *N. vitis* appears to be confined to Vitaceae, and possibly only the genus *Vitis*, there may well be non-commercial grapes or other related creepers that are suitable hosts in nearby gardens.

Given that:

- uneaten fruit that carries life stages of *N. vitis* might be discarded in compost heaps or the environment;
- juveniles might complete their development to adults on discarded grapes;
- adults and possibly juveniles might disperse to acceptable hosts (*Vitis* spp. and possibly other Vitaceae) if these are nearby;

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

8.6.2.3 Establishment assessment

It is necessary for a male and a female moth to encounter each other for sexual reproduction to take place. Although it is not known if *N. vitis* use sex pheromones to facilitate this, it is likely because other Pterophoridae do so (for example the artichoke plume moth *Platyptilia carduidactyla* (Haynes and Birch, 1986)).

Known hosts are in the family Vitaceae and are not native to New Zealand, and their appearance in New Zealand's natural environment is limited. Grapes are grown by home gardeners, are fully naturalised, growing in the wild, and are grown in monoculture commercially. Other members of the family may be hosts and are most likely to be found around gardens and buildings, appearing only casually in the wild. The potential for spread may be limited unless the insect is in an area where commercial vineyards are found. However, movement of infested plant material, particularly grape bunches, would assist spread round New Zealand.

Because *N. vitis* is known to occur in Japan, Korea and China, it is assumed that some areas of New Zealand, particularly in the North Island, would be climatically suited to this species.

Given that:

- reproduction is sexual so at least one individual of each sex is required to start a reproducing population;
- it is likely that pheromones would facilitate mate finding;
- known hosts are in the introduced family, Vitaceae, and appear in New Zealand's modified environments;
- the known distribution of *N. vitis* suggests at least parts of New Zealand would have a suitable climate;

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

8.6.2.4 Consequence assessment

Economic consequences

As *N. vitis* has emerged as a pest of grapes in China in recent years (Zheng *et al*, 1993 [from CAB Abstracts]), the potential in New Zealand is likely to be similar. Damage to leaves, stems and fruit result in severe fruit fall and partially abnormal fruit which would directly impact on vine productivity. Indirect consequences could include an increase in pest control costs and/or disruption of existing control programmes, particularly those based on IPM. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- damage by *N. vitis* would decrease grapevine productivity if not controlled;
- controlling *N. vitis* could increase pest control costs in vineyards in New Zealand;

The potential economic consequences are considered to be low to moderate and therefore non-negligible.

Environmental consequences

N. vitis has been recorded on *Vitis* species and possibly attacks other species in the family Vitaceae. In New Zealand there are no native species in this family. Damage to the three other species in Vitaceae that either fully naturalised (*Parthenocissus inserta* Virginia creeper) or make a casual appearance in the wild (*Cissus striata* miniature grape ivy, *P. tricuspidata* boston ivy), along with that on non-commercial grapevines might be of concern to gardeners but would otherwise be of low impact to the environment.

Given that:

- *N. vitis* has not been recorded on plants outside the family Vitaceae;
- New Zealand has no native species in the family Vitaceae;
- damage to species of Vitaceae in gardens might be of concern to gardeners;
- damage to the species of Vitaceae in New Zealand's natural environment would be of low impact to that environment;

The potential environmental consequences are considered to be extremely low and therefore non-negligible.

Human health consequences

There is no evidence that *N. vitis* is of any significance to human health.

8.6.2.5 Risk estimation

The likelihood of entry is considered to be low, the likelihood of exposure is considered to be low, and the likelihood of establishment is considered to be low. The potential economic consequences are considered to be low to moderate and the potential environmental consequences are considered to be extremely low, while no health consequences are expected. *As a result the risk estimate for* Nippoptilia vitis *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

8.6.2.6 Assessment of uncertainty

How well suited *N. vitis* is to New Zealand climates, particularly those of grape growing regions, is not known. However, given that it occurs in Japan, Korea and China, it is assumed that some regions in New Zealand, particularly in the North Island, will be suitable for establishment.

The distribution of *N. vitis* throughout China is unclear, although it is known in at least some of the grape-producing regions (Jilin and Guizhou).

Biological information is very limited. More information on life history, dispersal, development requirements, would help determine likelihood of entry, establishment, spread, and consequences. For example, how far larvae disperse is not known and it has been assumed that they do not disperse far.

8.6.3 Risk management

8.6.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or ISPM 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. The distribution of *N. vitis* in China is unclear although it is recorded in Jilin and Guizhou Provinces. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *N. vitis*.

Bagging

The practice of bagging individual fruit is likely to prevent *N. vitis* from accessing the fruit surface. However, bagging will only be a viable risk mitigation option if the bags are in place during the whole growing season, right up until harvest of the grapes. If bagging occurs until harvest it is considered a viable option when combined with phytosanitary visual inspection.

Pre-export phytosanitary visual inspection

N. vitis causes damage to fruit that is expected to be detectable upon pre-export phytosanitary visual inspection. Therefore inspection of consignments before export will assist in reducing the likelihood of entry of *N. vitis*. Since there is little information on this pest, whether pre-export phytosanitary visual inspection will be sufficient is uncertain. However, pre-export phytosanitary visual inspection is considered a viable option when combined with bagging.

Cold treatment

Adults are the overwintering stage, so it may be possible to kill other stages by exposing grapes to low temperatures. Since there is little information on this pest, whether cold treatment will be sufficient is unknown. Therefore, cold treatment is not considered a viable single option to mitigate the risk.

Methyl bromide

There is very little information on *N. vitis* or this family within the Lepidoptera. The assumption is made that a methyl bromide treatment against other Lepidoptera moths would be effective against *N. vitis.* The Plant Protection and Quarantine Department of the USDA currently recommends one of following methyl bromide treatments against the grapevine moth *Lobesia botrana* (Lepidoptera: Tortricidae) on grapes (TQAU USDA, 2008) (accessed 23/02/2009):

Table 19. Treatment T101-h-2

Temperature (ºC)	Rate (g/m3)	Minimum Concentration Readings (g/m3) at:	
		0.5 hr	2 hrs
26.67ºC or above	24	19	14
21.11 to 26.11ºC	32	26	19
15.56 to 20.56ºC	40	32	24
10.00 to 15.00ºC	48	38	29
4.44 to 9.44ºC	64	48	38

Table 20. Treatment T101-h-2-1

Temperature (ºC)	Rate (g/m3)	Minimum Concentration Readings (g/m3) at:					
		0.5 hr	2 hrs	2.5 hrs	3 hrs	3.5 hrs	4 hrs
21.11 ºC or above	32	26	22	22	–	21	–
18.33 to 20.56ºC	32	26	22	22	–	–	19

Alternatively, the treatments as described against *Bactrocera dorsalis* will be equally as effective (TQAU USDA, 2008).

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, the treatment must kill 99.9968% of the pests in a test of at least 100 000 individual pests. No treatment efficacy level is provided for these specific treatments. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *N. vitis* or if evidence is provided of the efficacy against *N. vitis* on table grapes, then methyl bromide fumigation is considered a viable option.

8.7 *Oraesia* spp. and *Calyptra lata* – fruit piercing moths

Due to similarities in the biology the following two *Oraesia* species and *Calyptra lata* (which used to be in the same genus) have been assessed as a group:

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: *Calpe lata*; *Oraesia lata*
Common names: fruit-piercing moth

8.7.1 Hazard identification

8.7.1.1 New Zealand status

O. emarginata, *O. excavata* and *C. lata* are not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2009) (accessed 08 Feb 2009).

8.7.1.2 Biology

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, grape and citrus, and overwinter as larvae in clusters of weeds and soil cracks around *Cocculus trilobus* (Family: Menispermaceae) (Liu and Kuang, 2001) which has also been recorded as a larval host plant for both species in Korea (Kim and Lee, 1985). 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* is on average between 1023 and 1224 and the maximum was 1830 (Ogihara *et al*, 1996).

Adults of both *O. emarginata* and *O. excavata* damage the fruit of their respective host plants (Yoon and Lee, 1974; Younghusband, 1980; Zhang, 1994; Liu, 2002; Liu and Kuang, 2001). In Korea, both *O. emarginata* and *O. excavata* adults pierce fruit of grapevines. By early October, the incidence of damage increased to 20% (Yoon and Lee, 1974). The larval stages of these species, however, do not attack the fruit of grape plants (Hanken 2000 (revised 2002)).

Cocculus trilobus, which is a member of the Menispermaceae and has grape-like drupes or fruit, has been recorded as a larval host plant in China (Liu and Kuang, 2001). *C. trilobus* has also been recorded in Korea as a larval food plant for both species in the vicinity of fruit orchards (Kim and Lee, 1985). (In addition, *Thalictrum aquilegifolium* [given as *Thalictrum aquilegifol*] (Ranunculaceae) was recorded as a larval food plant for *O. excavata* in the vicinity of the same orchards.) In Zimbabwe, the only recorded larval food plants of *C. emarginata* (and two other species of *Oraesia*) are members of the Menispermaceae family (Younghusband, 1980). Vines in the family Menispermaceae provide food for larvae of the principal fruit-piercing moths in Australia, and in most of the Old World tropics and near tropics (Fay, 1996). Only the adult moth attacks fruit. The adults are associated directly with the fruit and fruit clusters of grape and grape plants, but they only do so at night when they fly into orchards to feed and then depart (Hanken, 2000 (revised 2002)).

Little information is available on *Calyptra lata*. AQSIQ (2009) reports that, as with 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.

8.7.1.3 Hosts

Oraesia emarginata: *Cocculus trilobus* (Zhang, 1994; Liu, 2002; Liu and Kuang, 2001; Kim and Lee, 1985); *Citrus* spp. (Liu, 2002; Liu and Kuang, 2001; CPC, 2007); *Pyrus* (Biosecurity Australia, 2005); *Prunus persica*, *Eriobotrya japonica* (Liu, 2002; Liu and Kuang, 2001), *Vitis* (AQSIQ, 2007, Kim and Lee, 1986; Yoon and Kim 1976).

Oraesia excavata: Cocculus trilobus (Kim and Lee, 1985); *Malus domestica*, *Prunus persica*, *Prunus dulcis* (Liu, 2002); *Pyrus* sp. (CPC, 2007; Liu, 2002; Liu and Kuang, 2001); *Vitis* spp. (Zhang, 1994); *Eriobotrya japonica*, *Citrus* sp. (Liu, 2002; Liu and Kuang, 2001).

Calyptra lata: orange is the main host for the adult, but the fruit of apple, plum, pear, peach, apricot and grape are also damaged (AQSIQ, 2009).

8.7.1.4 Plant parts affected

Adults are associated with fruit (Yoon and Lee, 1974); larvae are associated with plants of the Menispermaceae family (Younghusband, 1980).

8.7.1.5 Geographic distribution

Both *O. emarginata* and *O. excavata* have similar distributions throughout Asia: China (Liu, 2002; Liu and Kuang, 2001; CPC, 2007); India (CPC, 2007); Korea (Kim and Lee, 1985; Park *et al*, 1988); Japan (Ogihara *et al*, 1992); Thailand (Zhang, 1994). *O. emarginata* is also found in Vanuatu (Muniappan *et al*, 2002) and in Zimbabwe (Younghusband, 1980) and has been recorded in South Africa (Myburgh, 1963).

C. lata reportedly occurs in some regions of China (for example, Hunan, Hebei and Yunnan Provinces) (AQSIQ, 2009), and in Korea (Lee *et al*, 1970; Park *et al*, 1988).

8.7.1.6 Hazard identification conclusion

O. excavata¸ *O. emarginata* and *C. lata* have been recorded on grapevine, and are associated with the grapes. They are present in China. They are not known to be present in New Zealand, and are therefore considered to be a potential hazard.

8.7.2 Risk assessment

8.7.2.1 Entry assessment

Only the adults of these species are associated with fruit. The adults are nocturnal, whereas the grape bunches are harvested during the day. The moths are relatively large (*O. emarginata*: 16–19 mm, *O. excavata*: 23–26 mm, *C. lata*: 25 mm) and are highly mobile (Liu and Meng, 2003; USDA, 2006; AQSIQ, 2009). Therefore, adults are highly unlikely to be associated with the fruit during harvesting, or remain with the fruit up until shipment.

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.

8.7.2.2 Risk estimation

The likelihood of entry is considered to be negligible. *As a result the risk estimate for* Oraesia emarginata, O. excavata *and* C. lata *is negligible and they are not classified as hazards in the commodity. Therefore risk management measures are not justified.*

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

8.7.2.3 Assessment of uncertainty

There is little information on *Oraesia excavata* and *Calyptra lata*. It is assumed that their biology is similar to that of *O. emarginata.*

8.8 *Peridroma saucia* – pearly underwing moth

Scientific name: *Peridroma saucia* (Hübner, 1808) (Lepidoptera: Noctuidae)
Other relevant scientific names: *Agrotis angulifera*; *Lycophotia margaritosa*; *Lycophotia ochronota*; *Lycophotia saucia* (Hübner); *Noctua aequa*; *Noctua majuscula*; *Noctua margaritosa*; *Noctua saucia*; *Peridroma argaritosa*; *Rhyacia saucia* (Hübner)
Common names: pearly underwing moth, variegated cutworm

8.8.1 Hazard identification

8.8.1.1 New Zealand status

Peridroma saucia is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2009).

8.8.1.2 Biology

The larvae of *Peridroma saucia* have been recorded on more than 130 angiosperms, preferring primarily herbaceous dicotyledonous plants, woody shrubs, low-growing fruit trees, and 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; accessed June 2009).

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 and in greenhouses on crops such 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, and in some cases almost the entire fruit was 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 3.5 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).

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 over 2000, on weeds surrounding the host plants or on the ground.

Larvae attack fruit as well as 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 consisted 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).

8.8.1.3 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) including grapevine, which is a minor host (Dibble *et al*, 1979; CPC, 2007).

8.8.1.4 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.’

8.8.1.5 Geographical distribution

P. saucia has been recorded in many countries in 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).

8.8.1.6 Hazard identification conclusion

P. saucia has been recorded on grape vine, and is associated with the fruit. It is present in China and is not known to be present in New Zealand. Therefore, *Peridroma saucia* is considered to be a potential hazard.

8.8.2 Risk assessment

8.8.2.1 Entry assessment

P. saucia is primarily a foliage feeder. There are reports of larvae feeding on fruit of orchard trees in the event of population outbreaks. Large numbers are likely to be present in such situations and the presence of the pest in the vineyard would be very evident. Given that an outbreak would be an unusual and obvious event, the chance of infested fruit being harvested is very unlikely.

The likelihood of entry is considered to be negligible.

8.8.2.2 Risk estimation

The likelihood of entry of *Peridroma saucia* on table grapes from China is considered to be negligible. *As a result the risk estimate for* Peridroma saucia *is negligible and it is not classified as a hazard on the commodity. Therefore risk management measures are not justified.*

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

8.8.2.3 Assessment of uncertainty

The association between the larvae of *Peridroma saucia* and grape bunches is uncertain.

8.9 *Spirama retorta* – fruit sucking moth

Scientific name: *Spirama retorta* (Clerck, 1764) (Lepidoptera: Noctuidae)
Other relevant scientific names: *Phalaena retorta*
Common name: fruit sucking moth

8.9.1 Hazard identification

8.9.1.1 New Zealand status

Spirama retorta is not known to be present in New Zealand. Not recorded in: Hoare (2001), Dugdale (1988), PPIN (2009) (accessed 17/02/2009).

8.9.1.2 Biology

S. retorta is a fruit sucking moth with larvae that defoliate trees. The development from egg to adult takes 42 days and goes through seven instars (biology is according to Sajap *et al*. (1997) unless stated otherwise).

Eggs are about 1 mm in diameter. The eggs are spherical and remain covered by a hard chorion (Sambath and Joshi, 2004). In a laboratory study in Malaysia, newly eclosed larvae were about 10 mm. The larval instars from one to seven took an average of 2.8 days, 2.5 days, 2.8 days, 2.8 days, 3.9 days, 3.8 days and 8.1 days, respectively. The larvae chewed minute holes in the leaves at first, but later they consumed all the leafy parts except the veins. Mature larvae pupated in an earthen cell at 10 to 20 mm in the vermiculite substrate. The pupae were about 30 mm in length. The pupation period was an average of 12.6 days, while the adult male and female lived 5.2 and 6.3 days respectively. In a laboratory study in India, mating began two days after emergence, followed by oviposition starting one or two days later. The female moth oviposited continuously for 6–8 days and eggs were laid in 6 to 8 instalments (Sambath and Joshi, 2004). Oviposition occurs at night (Sambath and Joshi, 2004). Females reared in the laboratory had a fecundity rate ranging from 208 to 307 eggs per female. In contrast, in the field females lay between 250 to 680 eggs on soft growing shoots, leaf margins and bushes around the host plants (Sambath and Joshi, 2004).

Females emerge earlier and in higher numbers than the males (Sambath and Joshi, 2004). The wingspan ranged from an average of 64.4 mm for the female to 58.8 mm for males. The total body length was an average of 21.3 mm for females and 20.0 mm for males (Kumar *et al*, 2002).

Seasonal occurrence in Korea showed three peaks, in early July, late July and early September. In India *S. retorta* was more abundant during August and September (Kumar *et al*, 2004). *S. retorta* has been recorded damaging young foliage and shoots (Sambath and Joshi, 2004). There can be up to seven generations (Sambath and Joshi, 2004). The small active instar larvae feed on epidermal tissues by gnawing on the ventral side of host leaves (Sambath and Joshi, 2004). In India, heavy damage is recorded from July to October in nurseries and young plantations, with the percentage of damage varying from 10 to 100% (Sambath and Joshi, 2004). In a study in Malaysia, about 8% of infested *Acacia magium* trees had more than 20 larvae per tree. These trees suffered defoliation rates of 20 to 30%.

During the day the larvae hide in leaf litter. The moths rest during the day hours (Sambath and Joshi, 2004).

8.9.1.3 Hosts

Albizia sp. (Sambath and Joshi, 2004), plum, peach, grapevine, apple (Kim and Lee, 1985), *Acacia mangium* (Sajap *et al*, 1997).

8.9.1.4 Plant parts affected

Larvae feed on young foliage and shoots, whereas adults feed on fruits (Sajap *et al*, 1997; Sambath and Joshi, 2004; Kim and Lee, 1985; Hanken, 2000 (revised 2002)).

8.9.1.5 Geographic distribution

China (Nair, 2007), India (Sambath and Joshi, 2004), Malaysia (Sajap *et al*, 1997), Korea (Kim and Lee, 1985; Hanken, 2000 (revised 2002)).

8.9.1.6 Hazard identification conclusion

Spirama retorta has been recorded on grape vine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *S. retorta* is considered to be a potential hazard.

8.9.2 Risk assessment

8.9.2.1 Entry assessment

Eggs are laid on soft growing shoots, leaf margins or bushes. The small active instar larvae feed on epidermal tissues by gnawing on the ventral side of host leaves (Sambath and Joshi, 2004). Only the adults of *S. retorta* are associated with fruit and they are nocturnal. Since grape bunches are harvested during the day it is highly unlikely that the adults would be associated with the fruit during harvesting, or that they would remain with the fruit, since they are highly mobile.

Given that:

- only the adults are associated with the fruit of grapevine;
- the adults are highly mobile, being strong fliers;
- the adults are nocturnal and therefore unlikely to be associated with fruit while it is being harvested;
- the adults are likely to be disturbed and fly away if present on fruit at harvest;
- the adults are large (with total body length around 2 cm) and therefore readily visible

The likelihood of entry is considered to be negligible.

8.9.2.2 Risk estimation

The likelihood of entry for *Spirama retorta* on table grapes from China is considered to be negligible. *As a result the risk estimate for* S. retorta *is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

8.9.2.3 Assessment of uncertainty

There is limited information available about the distribution of *S. retorta* within China. Also the information on the damage of this pest to grapevine is limited.

8.10 *Xestia c-nigrum* – spotted cutworm

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; *Graphiphora 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

8.10.1 Hazard identification

8.10.1.1 New Zealand status

Xestia c-nigrum is not known to be present in New Zealand. Not recorded in: Dugdale (1988), Hoare (2001), PPIN (2009) (Accessed 10/02/2009).

8.10.1.2 Biology

Xestia c-nigrum has one to three generations per year. In warmer climates such as Southern Europe, three generations occur, but at higher elevations in Japan, there is only one (CPC, 2007) (accessed 10/02/2009).

Overwintering takes place when larvae are mature and there is no diapause stage, thus larvae are able to start feeding as soon as conditions are warm enough to allow for movement (TFREC, 2008) (Accessed 10/02/2009). Pupation occurs in the soil in silk-lined chambers (CPC, 2007).

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 when temperatures are around 20°C, and when temperatures average 15°C, the egg stage lasts for up to 12 days. Eggs are rounded when viewed from above and slightly flattened, 0.6 mm wide and 0.5 mm high (CPC, 2007).

Spotted cutworm larvae spend the days sheltered in the ground cover and feed nocturnally on tree fruit hosts. The larvae will leave a chemical trail and often return to the same shoot to feed on successive days (TFREC, 2008; DEVTB, 2009). The mature larvae is 30–35 mm long and 6–7 mm wide at the middle (CPC, 2007). During the summer the larvae normally passes through six (occasionally seven) stages before pupating. In the summer the 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 (Oku, 1985). The larvae often curl up tightly when disturbed. The larvae generally feed only on the lower central portion of the tree around the trunk, but under high population pressure, complete limbs or even whole trees may be stripped. Feeding by cutworms on the foliage or fruit during the autumn or summer is rare (DEVTB, 2009).

The mature larva has a prepupal resting phase that lasts from 2 to 11 days (depending on mean temperature). The larva buries itself in the soil and pupates in a silk-lined chamber. The pupal stage lasts for 3 weeks in warm weather, and for up to 5 weeks in early spring (CPC, 2007). In Russia, pupation took place in early June and adults emerged in early July and peaked in mid-July (Musich, 1976). The pupa of *X. c-nigrum* is 19–22 mm long and 6 mm wide (CPC, 2007).

In northern Japan, the summer generation of *X. c-nigrum* has six larval instars (Oku, 1984). Moreover, adults had two distinct flight periods in the plains and the lower hills, due to differences in temperature (Oku, 1984). Larvae enter the winter as 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 (CPC, 2007). Exposure to 10^{o}C was also effective in increasing the freezing tolerance of later-instar larvae. Both photoperiod and temperature appeared to be important for winter survival of this noctuid (Goto *et al*, 1986). After adults emerge from the pupal case they have a pre-oviposition period of 3 or 4 days in spring and summer and 4–6 days in the autumn. Adults are nocturnal and generally live for 2–3 weeks (CPC, 2007). In San Joaquin Valley, California, *X. c-nigrum* feeds on the buds of grapevines, causing serious damage early in the season (Dibble *et al*, 1979).

8.10.1.3 Hosts

X. c-nigrum has been recorded on a wide range of more than 70 angiosperms, preferring primarily herbaceous dicotyledonous plants and low-growing shrubs, but occasionally feeding on fruit trees and grasses. *Vitis vinifera* is a major host (CPC, 2007; Dibble *et al*, 1979). 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).

8.10.1.4 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).

8.10.1.5 Geographic distribution

X. c-nigrum is widespread in Canada, the USA, Europe and Asia, including China, Korea, India, Japan and Vietnam (CPC, 2007; Lu *et al*, 1995; Oku, 1985; Li and Ma, 1934).

8.10.1.6 Hazard identification conclusion

Xestia c-nigrum has been recorded on grape vine, and is associated with the fruit. It is present in China and is not known to be present in New Zealand. Therefore, *Xestia c-nigrum* is considered to be a potential hazard.

8.10.2 Risk assessment

8.10.2.1 Entry assessment

Eggs, pupae and adults of *Xestia c-nigrum* are not associated with fruit. Mature larvae are large: 30–35mm long and 6–7mm wide (CPC, 2007). They would be visible to the naked eye, as would the feeding wounds on fruit. Feeding by cutworms on the fruit during the summer or autumn is rare (DEVTB, 2009).

The larvae are external feeders, feeding on fruit trees only at night and returning to the ground cover to hide during the day (TFREC, 2008; DEVTB, 2009). They are unlikely to be associated with the fruit during harvest (daytime). *Xestia c-nigrum* are unlikely to remain with the grape bunches on the pathway from China to New Zealand.

Given that:

- only the larvae are associated with the fruit of grapevine;
- larvae are unlikely to be associated with the fruit during the harvest process;
- larvae and their damage are readily visible;

The likelihood of entry is considered to be negligible.

8.10.2.2 Risk estimation

The likelihood of entry of *Xestia c-nigrum* on table grapes from China is considered to be negligible. *As a result the risk estimate for* Xestia c-nigrum *is negligible and it is not classified as a hazard in the commodity. Therefore risk management measures are not justified.*

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

8.10.2.3 Assessment of uncertainty

There is uncertainty about the distribution of *X. c-nigrum* on grape throughout China.

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9 Risk assessment of potential hazards – Thysanoptera (thrips)

9.1 *Rhipiphorothrips cruentatus* – grapevine thrips

Scientific name: *Rhipiphorothrips cruentatus* Hood, 1919 (Thysanoptera: Thripidae)
Other relevant scientific names: *Rhipiphorothrips karna*
Common name: grapevine thrips

9.1.1 Hazard identification

9.1.1.1 New Zealand status

Rhipiphorothrips cruentatus is not known to be present in New Zealand. Not recorded in: Mound and Walker (1982), PPIN (2009) (accessed 24-03-2009).

9.1.1.2 Biology

R. cruentatus is one of the most important insect pests of grapevine in India (Batra *et al*, 1986). The eggs are 0.3 mm long, they are laid singly on the underside of the leaf and change in colour from greenish to dirty white when aging (biology is according to Rahman and Bhardwaj (1937) unless stated otherwise). The number of eggs laid ranges from 15 to 50. They hatch in 3 to 8 days, depending on the time of the year.

The four immature stages are two nymphal instars, a pre-pupal and a pupal stage. The body lengths of these stages are 0.8 mm, 1.4 mm, 1.2 mm and 1.5 mm, respectively. The total duration of the immature stages varies from 11 to 25 days.

The adults are between 1.2 and 1.5 mm long and blackish brown in colour. The nymphs are yellowish-white (Batra *et al*, 1986). The adults mate two to ten days after emergence from pupae. Two to seven days after mating the male dies, while the female can live for up to 20 days. Pupation occurs on the leaves during the active season, but before winter the nymphs move to the soil where they pupate and the adults appear next spring (Batra *et al*, 1986; Rahman and Bhardwaj, 1937). The adults mostly die off during autumn.

Sexual reproduction is common, although parthenogenesis does occur simultaneously. The parthenogenetically developed offspring consists of males only. The life cycle is temperature dependent, with more eggs being produced and life cycle length reduced at higher temperatures. Pupae hibernate in India, while in Taiwan *R. cruentatus* breeds continuously (CPC, 2007). During the active period the life-cycle takes 14 to 33 days and there are 5 to 8 generations a year.

Both nymphs and adults feed on the underside of the leaves and on developing berries, often in groups (Kulkarni *et al*, 2007; Batra *et al*, 1986). On rare occasions, they feed on the upper side of the leaves, mainly when the lower surface is completely destroyed. They feed by rasping the surface with their stylets and sucking on the oozing cell sap. The leaves can turn brown and necrotic during heavy infestations. When the attacked leaf begins to dry, the adults and nymphs migrate to new healthy leaves. The attacked berries appear scabby, develop a corky layer and become brown (Kulkarni *et al*, 2007; Batra *et al*, 1986). Varieties of grapevines with thicker leaves, hairy on the lower surface, are resistant to attack by *R. cruentatus* (CPC, 2007).

9.1.1.3 Hosts

R. cruentatus is polyphagous: its larvae have been found on a range of plants, many of which have rather hard leaves. Major hosts are *Anacardium occidentale* (cashew nut), *Annona squamosa* (sugarapple), *Mangifera indica* (mango), *Psidium guajava* (guava), *Punica granatum* (pomegranate), *Rosa rugosa* (Rugosa rose), *Syzygium cumini* (black plum), *Syzygium samarangense* (water apple), *Terminalia catappa* (Singapore almond), *Vitis vinifera* (grapevine) (CPC, 2007; Rahman and Bhardwaj, 1937).

9.1.1.4 Plant parts affected

Leaves and fruit (Kulkarni *et al*, 2007; Batra *et al*, 1986; Rahman and Bhardwaj, 1937)

9.1.1.5 Geographic distribution

R. cruentatus is widespread in India and Sri Lanka, and has also been recorded from Afghanistan, Bangladesh, Myanmar, Oman, Pakistan, and Thailand (CPC, 2007).
It is present in China (CPC, 2007; Batra *et al*, 1986; Zhang, 1980; Rahman and Bhardwaj, 1937; Han, 1996). *R. cruentatus* has been reported from Guangdong, Hainan and Guangxi (Hua, 2000).

9.1.1.6 Hazard identification conclusion

Rhipiphorothrips cruentatus has been recorded on grapevine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *R. cruentatus* is considered to be a potential hazard.

9.1.2 Risk assessment

9.1.2.1 Entry assessment

Grapevine is a major host of *R. cruentatus*. This thrips is one of the most important insect pests of grapevine in India where it is widespread. However, its distribution in Chinese vineyards is uncertain. Observations in India suggest that varieties of grapevines with thicker leaves that are hairy on the lower surface are resistant to attack by *R. cruentatus* (Rahman and Bhardwaj, 1937). However, the distribution in China of grapevine varieties with this characteristic is not known.

R. cruentatus eggs are laid singly on the underside of the leaf and are not associated with fruit. Nymphs and adults usually occur on leaves but will also feed on developing fruit. This observation suggests that their occurrence is less likely on mature fruit at the time of harvest but this cannot be ruled out. Pupation occurs on leaves during the active season, but before winter the nymphs move to the soil to pupate. However, given that nymphs can feed on developing fruit it is possible they could sometimes pupate within the shelter of the grape bunch, even though this has not been recorded.

It is claimed that *R. cruentatus* should be found relatively easily during quarantine inspections because adults are easily observed on leaves and that nymphs tend to cluster in groups close to adults (CPC, 2007). Therefore it should be possible to detect adults and nymphs on grape berries even though they are small. However, both these stages (and pupae, if present) could escape detection if hidden in the interior of the grape bunch. Infested berries appear scabby and become brown and are likely to be discarded during the harvest and packing processes.

Given that:

- grapevine is a primary host for *R. cruentatus*;
- although *R. cruentatus* has been recorded in China, its prevalence in grape-growing areas is unknown;
- adults and nymphs, (and possibly pupae), although primarily found on leaves and sometimes on developing fruit, may be present on the mature fruit at the time of harvest;
- the small size of the thrips means that a standard grading and packing process could miss them if infestation levels are low or if they are concealed inside the grape bunch;
- heavy infestations are likely to be detected
- damaged grapes will be discarded during the harvest and packing process'

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

9.1.2.2 Exposure assessment

Following post-border distribution of imported grapes, any associated thrips need to disperse and locate suitable hosts. The potential for dispersal depends on the life stage and sex. In an absolutely calm atmosphere *R. cruentatus* is capable of leaping from one leaf to another. The distance that can be covered in one jump is a maximum of 30 cm for females and 24 cm for males. A female can crawl up to a distance of 23 cm over water, while a male can reach up to 13 cm. Moreover, 150 minutes submergence results in 20% of thrips still being viable. This indicates that heavy rains do not affect *R. cruentatus* adversely (Rahman and Bhardwaj, 1937). Thrips are largely dependent on strong winds for dispersal over larger distances. Strong winds are a feature of the New Zealand climate and could aid rapid dispersal. 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 (Rahman and Bhardwaj, 1937). *R. cruentatus* is polyphagous, but most of the listed major hosts are not widely distributed throughout New Zealand. Grapevine is regarded as a major host and there may well be non-commercial grapes or other related creepers that are suitable hosts in nearby gardens. In addition, exotic and native plants in the same families as known hosts of *R. cruentatis* (for example, Myrtaceae and Rosaceae) are found in domestic gardens and parks in New Zealand, and the natural environment.

Given that:

- uneaten fruit that carries life stages of *R. cruentatus* might be discarded in compost heaps or the environment;
- juveniles might complete their development to adults on discarded grapes;
- adults are capable of dispersing short distances actively and longer distances passively by wind currents;
- adults that are wind dispersed are unable to actively choose to land on a suitable host plant;
- *R. cruentatus* is polyphagous and although many listed major hosts would not occur widely through New Zealand, acceptable hosts, particularly grapevine, may be available in modified habitats;

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

9.1.2.3 Establishment assessment

Sexual reproduction is common, although parthenogenesis does occur simultaneously which means that females that have not been fertilised can produce male offspring. *R. cruentatus* often feeds in groups, increasing the likelihood of their locating a mate.

The limited dispersal ability and limited distribution of known major hosts (other than grapevine) in New Zealand suggests that spread is likely to be slow and will probably depend on human assisted transport of infested material or wind (Rahman and Bhardwaj, 1937). Which wild hosts *R. cruentatus* can infest is uncertain as the hosts listed are mainly economic plants and.

R. cruentatus occurs widely throughout Asia. Before winter the nymphs move to the soil where they pupate and the adults appear next spring. Adults are cold sensitive, exposure to 4°C for at least 5 hours results in 100% mortality. This would make most of the South Island and the higher parts of the North Island unsuitable for adult stages for at least 5 months a year (NIWA 2008). The cold tolerance for pupae is unknown. *R. cruentatus* pupates in the soil in India over winter which suggests considerable cold tolerance in this stage, which could still mean that most vine growing areas in NZ would be suitable. Many grape pests in NZ hibernate overwinter in a resistant stage.

Given that:

- unfertilised females can produce male offspring asexually which would then enable sexual reproduction to occur;
- known hosts include grapevine which appears in New Zealand's modified environments;
- at least some regions of New Zealand will have a suitable climate for *R. cruentatus* including many grapevine growing areas;

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

9.1.2.4 Consequence assessment

Economic consequences

Seriously damaged plants have reduced productivity and the grapes from these plants are of poor quality fetching low prices (Rahman and Bhardwaj, 1937; Kulkarni *et al*, 2007). Grapevines are grown throughout New Zealand and are an economically important crop. As well as a direct reduction in yield, the establishment of *R. cruentatus* could have indirect consequences such as increases in pest control costs and/or disruption of existing control programmes, particularly those based on IPM. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

The establishment of *R. cruentatis* could also have an effect on access to some markets. Other crops and industries such as cut flowers (for example roses) and the nursery industry, may also be affected.

Given that:

- damage by *R. cruentatis* would decrease productivity of grapes, and possibly other crops, if not controlled;
- controlling *R. cruentatis* could increase treatment costs for industries such as grapes and the nursery industry in New Zealand;
- access to some markets could be affected;

The potential economic consequences are considered to be moderate and therefore non-negligible.

Environmental consequences

R. cruentatis is polyphagous and some of the plant families in which it has hosts (for example, Rosaceae, Myrtaceae) also have New Zealand native members including endemic species (for example, *Syzygium maire*) and genera (for example, *Lophomyrtus*, *Neomyrtus*). The native tree species *S. maire*, for example, could potentially become an alternative host for the thrips if it established near native lowland forest in which this tree species predominantly occurs. In addition, exotic plant species in the same families as known hosts of *R. cruentatis* are found in domestic gardens and parks in New Zealand. For example, *R. cruentatis* attacks roses, which are a well known amenity plant and this could be of concern to gardeners.

Given that:

- *R. cruentatis*, which is polyphagous, could attack garden and amenity plants that are grown in New Zealand;
- *R. cruentatis* could attack and be damaging to some native plant species;

The potential environmental consequences are considered to be low and therefore non-negligible.

Human health consequences

Some thrips species can cause skin irritations as a result of trying to feed when coming into contact with human skin. No thrips species feed on blood and there is no known disease transmission resulting from such behaviour. There is no evidence in the literature that *R. cruentatus* has any negative impacts on human health. *The potential human health consequences of establishment are considered to be negligible.*

9.1.2.5 Risk estimation

The likelihood of entry is considered to be moderate, the likelihood of exposure is considered to be low and the likelihood of establishment is considered to be low. The potential economic consequences of establishment are considered to be moderate, while the potential environmental consequences of establishment are considered to be low. There are no known human health consequences. *As a result the risk estimate for* Rhipiphorothrips cruentatus *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

9.1.2.6 Assessment of uncertainty

Cold tolerance data for nymphs, pupae or eggs was not found. The distribution and the amount of damage caused by *R. cruentatus* within China are unclear. No major studies on host acceptance by *R. cruentatus* have been recorded, and its host range is not known.

9.1.3 Risk management

9.1.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. Pest free area status may be an option for table grapes exported from some provinces. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *R. cruentatus*.

Pre-export phytosanitary visual inspection

R. cruentatus is reportedly readily observed on leaves and fruit and should be found relatively easily during quarantine inspections (CPC, 2007). The thrips feed by rasping the leaf surface by their stylets and sucking on the oozing cell sap which usually leaves clear visual clues indicating an infestation. Similar evidence is assumed to be present on fruit.

Moreover, both nymphs and adults often feed in groups. Pre-export phytosanitary visual inspection is not considered a viable option if performed as a sample inspection.

Bagging

The different live stages of *R. cruentatus* are very small. The bagging of fruit is not expected to protect it from *R. cruentatus*. Bagging is currently not considered an option.

Cold treatment

When adults are exposed to 4°C for one hour, all survive, becoming active again 15 to 27 minutes after their removal from the cold temperature. Exposure to 4°C for at least 5 hours, results in 100% mortality (150 individuals tested at 3 timepoints). Males are less resistant to cold treatment than the females (Rahman and Bhardwaj, 1937). Transport to New Zealand at temperatures of 0–1°C is likely to be effective against adults. The tolerance of nymphs is unknown. If evidence is provided of the efficacy against all stages of *R. cruentatus* on table grapes in a large scale test, then cold treatment could be a viable option. Therefore, cold treatment is currently not considered a viable single option to mitigate the risk.

Methyl bromide fumigation

Fumigation of roses, tulips and carnation with a dose of 16 g/m^3 of methyl bromide at atmospheric pressure and a temperature of at least 30°C for 1.5 hours resulted in 100% mortality of *R. cruentatus* 12 hours after the treatment (1300 thrips tested in total). Directly after the treatment it resulted in 50% to 80% mortality (Junaid and Nasir, 1956). The Plant Protection and Quarantine Department of the USDA currently recommends one of following methyl bromide treatments against hitchhikers and surface pests such as thrips on grapes (TQAU USDA, 2008):

Table 21. Treatment T104-a-1

Temperature (ºC)	Rate (g/m^3)	Minimum Concentration Readings (g/m3) at:	
		0.5 hr	2 hrs
26.67ºC or above	24	19	14
21.11 to 26.11ºC	32	26	19
15.56 to 20.56ºC	40	32	24
10 to 15ºC	48	38	29
4.44 to 9.44ºC	64	48	38

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, the treatment must kill 99.9968% of the pests in a test of at least 100 000 individual pests. No treatment efficacy level is provided for these specific treatments. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *R. cruentatus* or if evidence is provided of the efficacy against *R. cruentatus* on table grapes, then methyl bromide fumigation is considered a viable option.

9.2 *Scirtothrips dorsalis* – chilli thrips

Scientific name: *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae)
Other relevant scientific names: *Neophysopus fragariae* Girault; *Heliothrips minutissimus* Bagnall; *Anaphothrips andreae* Karny; *Scirtothrips dorsalis* var. *padmae* Ramakrishna; *Scirtothrips fragariae* (Gault); *Scirtothrips minutissimus* (Bagnall)
Common names: chilli thrips, yellow tea thrips, strawberry thrips, Assam thrips

9.2.1 Hazard identification

9.2.1.1 New Zealand status

Scirtothrips dorsalis is not known to be present in New Zealand. Not recorded in: Mound and Walker (1982), PPIN (2009) (accessed 25/02/2009).

9.2.1.2 Biology

S. dorsalis is mainly a foliage feeder, but all above ground parts may be attacked (USDA-CSREES, 2007). The adult *S. dorsalis* is pale yellow with darker wings and it is about 0.8 mm in length (Amin and Palmer, 1985; CSL, 2006). Reproduction is sexual although unfertilised eggs can hatch haploid males (Amin and Palmer, 1985). Females oviposit into the soft tissues of young leaves and buds, into the epicarp of fruit such as mandarin and orange (often under the calyx), and to a lesser extent flowers (Amin and Palmer, 1985; CSL, 2006; Raizada, 1965; Nishino and Kodomari, 1988; Onkarappa *et al*, 1998).

Eggs are laid singly, about 2–3 per day. Females can lay up to 60 kidney-shaped eggs in their lifetime (Amin and Palmer, 1985). Tatara (1994) noted that 100% of the eggs hatched at 29.5˚C and 85.7% at 14.5˚C in experimental conditions. The first of the two larval stages is about 0.3 mm long at hatch, transparent in colour and long-legged (Raizada, 1965).

Pupation occurs in the soil or leaf litter (Raizada, 1965; Duraimurugan and Jagadish, 2004), in the leaf axils, leaf curls or under the calyces of flowers and fruit, in lichens and moss growing on tea bush stems, and in cracks and crevices in the stem (CSL, 2006).

The life cycle is usually completed in 15–18 days at temperatures above about 25˚C (Rajamma *et al*, 2004). The number of generations per year varies from an estimated 7–8 in Japan (Tatara, 1994) to up to 25 overlapping generations per year in India (Raizada, 1965). Female adult longevity varies from 6–18 days and adult males 4–5 days. The longevity is host dependent, in contrast with the development duration (Tatara, 1994). The usual sex ratio in the population is 6:1 in favour of females, almost constantly throughout the year (Raizada, 1965).

The developmental threshold was calculated as being 8.5˚C and 294 degree-days for egg to adult development on grape (Shibao, 1996).

Field identification is extremely difficult and often it is impossible to differentiate this thrips from other thrips (USDA-CSREES, 2007). The adult thrips are fast moving and will jump at slight disturbance, then fly a short distance. Larvae and adults feed on shoots, leaves, young fruit and flowers of host plants (Holtz, 2006). Host damage is most severe on young parts of the plant (Seal *et al*, 2006). The occurrence on shoots is influenced by the quantity of available lateral shoots (Shibao *et al*, 1993). The thrips attacks the leaves of kiwi fruit, but this does not lead to economic damage to this plant (Sakakibara and Nishigaki, 1988).

Adults overwinter on evergreen plants and migrate to grapes in the spring (Shibao, 1996). The adults lacerate the surface of tender fruits and feed on the sap that exudes. The infestation lasts till the time of fruit maturity (Ali *et al*, 1973). The proportion of damaged fruit clusters can reach 45 % (Shibao, 1996), but few adults and larvae are generally collected on fruit clusters (Shibao *et al*, 1993; Seal *et al*, 2006). The thrips also damages the rachis (Shibao *et al*, 1993). Information in the literature on the ability of *S. dorsalis* to breed on grapevine is conflicting. Some authors state that it does not breed on grapevine (Ali *et al*, 1973; Holtz, 2006) whereas other sources state that grapevine is a major host (for example CPC, 2007).

9.2.1.3 Vector

S. dorsalis is known to vector:

- Groundnut chlorotic fan-spot virus (CSL, 2006) (not recorded as present in NZ- Pearson *et al*, 2006))
- Yellow spot virus (YSV) on groundnuts ((CSL, 2006) (not recorded as present in NZ- Pearson *et al*, 2006))
- Tobacco streak virus (present in NZ – Pearson *et al*, 2006))

S. dorsalis was thought to vector Tomato spotted wilt virus which causes bud necrosis disease in peanuts (Amin and Palmer, 1985), however this thrips is not thought to be an efficient vector of TSWV and there appears to be some doubt if it does vector this virus at all (CSL, 2006).

9.2.1.4 Hosts

S. dorsalis is highly polyphagous. It has been recorded on more than 100 plant species spread across 40 families (CSL, 2006). Major hosts include *Allium cepa* (onion), *Capsicum frutescens* (chilli), *Citrus* spp., *Diospyros kaki* (persimmon), *Lycopersicon esculentum* (tomato), *Mangifera indica* (mango), *Vitis vinifera* (grape)(Nietschke *et al*., 2008). Other hosts include *Acacia* spp., *Actinidia chinensis* (kiwifruit), *Allium cepa* (onion), *Cucumis* spp., *Ficus carica* (common fig), *Fragaria* × *ananassa* (strawberry, *Phaseolus vulgaris* (bean), *Prunus* spp., *Pyrus* spp. and *Rosa* spp.(CPC, 2007) (accessed 02/03/2009) (CSL, 2006; Raizada, 1965; Rajamma *et al*, 2004; Hodges *et al*, 2005; Yamaguchi, 2007; Li *et al*, 2004; Ciomperlik and Ludwig, 2007).

9.2.1.5 Plant parts affected

S. dorsalis adults and immatures feed on any soft part of the plant – shoots, leaves, buds, (young) fruits and flowers (CPC, 2007; Raizada, 1965; Yamaguchi, 2007; Rani and Sridhar, 2003). The growing tips, buds, young leaves and axillary leaf bunches are especially targeted (CSL, 2006; Holtz, 2006).

9.2.1.6 Geographic distribution

S. dorsalis is present in the USA, Hawaii, the Caribbean, Australia, Solomon Islands, Papua New Guinea, Côte d'Ivoire (although interception records suggest a wider distribution across West Africa and Kenya), Venezuela, Suriname. It is widespread in Asia, where it is present, among others, in China, India, Japan, Malaysia, Korea and Thailand (CSL, 2006; Nietschke *et al*, 2008; CPC, 2007; Hodges *et al*, 2005).

S. dorsalis is native in China and other parts of Asia. It has been reported as being on *Vitis vinifera* in China. It has been reported from Henan, Hubei, Anhui, Jiangxi, Jiangsu, Zhejiang, Fujian, Guangdong, Hainan, Hunan, Guangxi, Guizhou, Sichuan and Yunnan (Hua, 2000). The distribution in the USA is restricted (Florida, Hawaii) (CPC, 2007).

9.2.1.7 Hazard identification conclusion

Scirtothrips dorsalis has been recorded on grapevine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *S. dorsalis* is considered to be a potential hazard.

9.2.2 Risk assessment

9.2.2.1 Entry assessment

Although *S. dorsalis* is present in China, the records accessed have been from a small number of provinces in southern China and it is unclear how prevalent it would be in regions where grapes are grown for export.

S. dorsalis is mainly a foliage feeder, but all above ground parts may be attacked. Females oviposit into the soft tissues of young leaves and buds, into the epicarp of fruit such as mandarin and orange (often under the calyx), and to a lesser extent flowers. It is assumed that eggs will not be present on harvested grapes. The adult *S. dorsalis* is about 0.8 mm in length. Adults, larvae and eggs are all difficult to detect.

Larvae and adults feed on shoots, leaves, young fruit and flowers of host plants. Few adults and larvae are generally collected on fruit clusters. The adults lacerate the surface of tender fruits and feed on the sap that exudes. The infestation lasts till the time of fruit maturity. The thrips also damages the rachis. *Scirtothrips dorsalis* is a significant pest of roses and has been intercepted at the New Zealand border around 17 times since 2003 on rose stems (MAFBNZ, 2009). All life-stages of *S. dorsalis* have been intercepted on mature fruit whereas previously it was not expected to be transported on mature fruit (CSL, 2006). Adult thrips are fast moving and will jump at slight disturbance, then fly short distance and so are unlikely to remain on harvested fruit. Sap exudate on infested fruit may mean that they are likely to be discarded during the harvest and packing processes. Larvae on fruit are the most likely life stage to be transported in table grapes, however it is also possible that they could pupate in the shelter of a grape bunch despite a tendency to drop to the soil or leaf litter for pupation.

Given that:

- it is uncertain how prevalent *S. dorsalis* is in regions where grapes are grown for export
- eggs, which tend to be laid in the soft tissues of young leaves and buds, may not be laid on grapevine;
- although the larvae can feed on young fruit, they are rarely found on fruit clusters and are unlikely to be present on mature fruit;
- feeding damage causes scaring and bronzing of fruit which would be discarded at harvest
- although *S. dorsalis* has been intercepted on other commodities on various pathways, its life history is short and it may not survive transport unless by air;
- pupae tend to drop to the soil or leaf litter rather than remain on the host plant, but could pupate within the shelter of the grape bunch;
- adults are mainly found on leaves or sometimes young fruit, but if present on mature fruit are likely to disperse during harvest and processing;
- life stages small and may not be detected at low levels especially if hidden inside grape bunch;

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

9.2.2.2 Exposure assessment

Pedicels, peduncle and uneaten berries of imported grapes will be thrown away. If these are thrown in compost heaps or on the side of the road, the thrips might be able to spread to plants in the vicinity. Although thrips are weak fliers they can be carried long distances by the wind. *S. dorsalis* is highly polyphagous and has been recorded on more than 100 plant species spread across 40 families (CSL, 2006), many of which are known amenity species. Therefore, an abundance of host material would be available within short distances in city centres and suburban areas for this polyphagous species.

Given that:

- uneaten fruit that carries life stages of *S. dorsalis* may be discarded in compost heaps or the environment;
- juveniles might complete their development to adults on discarded grapes;
- adults and possibly juveniles might disperse to other nearby plants;
- thrips that are wind dispersed are unable to actively choose to land on a suitable host;
- *S. dorsalis* is polyphagous, and acceptable hosts are widely available in suburban areas and domestic gardens;

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

9.2.2.3 Establishment assessment

Reproduction is sexual although unfertilised eggs can hatch haploid males. Sex ratio is skewed 6:1 to females but few adults and larvae are generally collected on fruit clusters, so the likelihood of finding an adult of the opposite sex is low. Arrhenotokous parthenogenesis could provide the necessary males, but only if the female does not disperse and stays alive long enough for the eggs to hatch and the male offspring to develop to full adulthood. Then they need to locate that same single female. The lifecycle is usually completed in 15-18 days at temperatures above 25°C, while the female longevity varies from 6-18 days. The likelihood of this kind of reproduction occurring when there is only one female present is considered extremely low.

S. dorsalis is highly polyphagous and has been recorded on more than 100 plant species spread across 40 families (CSL, 2006), therefore there would be no shortage of hosts in the environment, particularly those that have been modified.

The developmental threshold has been calculated as being 8.5˚C and 294 degree-days on grape for egg to adult development (Shibao, 1996). Adults are the overwintering life stage in Japan, although in mild winters, the larvae, prepupae and pupae were able to overwinter (Holtz, 2006). In a prediction study for the potential establishment in the USA, a similar thrips species (*Thrips palmi*), which often occurs in mixed population with *S. dorsalis*, was used to set a lower lethal temperature level of -4˚C or below for 5 or more days (Nietschke *et al*, 2008). The average mean air temperature in the North Island is above 8.2˚C, except for some higher parts in the central North Island. The South Island has a high number of days with ground frost during winter months (NIWA 2008). This would make the northern part of New Zealand much more suitable for establishment, while the southern parts could be reinfested each year during summer.

Given that:

- both sexual and asexual reproduction can occur;
- *S. dorsalis* is highly polyphagous and acceptable hosts are widely available in modified environments in New Zealand;
- northern regions of New Zealand are more climatically suited to the establishment of *S. dorsalis;*

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

9.2.2.4 Consequence assessment

Economic consequences

S. dorsalis is highly polyphagous and of special significance to the flower industry, the wine industry, nursery and horticultural industries. Strawberries, grapes, citrus, tomato, capsicum, beans, ornamentals, cut-flowers (several species), eggplant, kiwifruit, cucumber, melon and asparagus are some of the plants likely to be affected. Control of thrips is difficult, the damage and loss of yield is costly. It is also a vector for several viruses, which would enhance economic damage as a result of establishment (Holtz, 2006). A preliminary analysis on the potential economic damage in the USA to 28 hosts of *S. dorsalis*, with an estimated 5% crop loss resulted in a total of $3 billion US dollars (Holtz, 2006). Losses in fruit yield vary from up to 25% in cashew to up to 90% in grapes (reviewed in CSL (2006)).

Access to markets in countries free of *S. dorsalis* is likely to be restricted. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- damage by *S. dorsalis* would decrease productivity of a number of commercial crops if not controlled;
- controlling *S. dorsalis* could increase pest control costs for a number of commercial crops in New Zealand;
- access to some overseas markets could be affected;

The potential economic consequences are considered to be high and therefore non-negligible.

Environmental consequences

As *S. dorsalis* is a polyphagous thrips it is likely to find hosts in the native flora. Native host plants are probably various Fabaceae (Smith *et al*, 1997). Several native species of Fabaceae are present in New Zealand, including *Carmichaelia* spp. (native brooms), *Clianthus puniceus* (kakabeak), *Montigena novae-zelandiae* and, most commonly, *Sophora* spp. (kowhai). *Sophora*, which has attractive yellow flowers, is widely planted through New Zealand as an amenity plant and the eight species range the full length of the country in native habitat, from coastal to forest environments. The other species are more limited in distribution, particularly *Montigena* and *Clianthus* which are rare with very restricted distributions. Most exotic pests that attack native plants are polyphagous, but highly damaging polyphagous species appear exceptional and it has been postulated that the impact of relatively specialised organisms is likely to be greater than highly polyphagous species (Beever *et al*, 2007). *S. dorsalis* is also known as a pest of a large group of ornamental plants (USDA-CSREES, 2007).

Given that:

- *S. dorsalis*, which is highly polyphagous, could attack garden and amenity plants that are grown in New Zealand;
- *S. dorsalis* could attack native plant species;

The potential environmental consequences are considered to be moderate and therefore non-negligible.

Human health consequences

Thrips can cause thysanoptera dermatitis by biting through human skin and sucking the epidermal lymph. The lesions formed are small, pink and itchy, often mistaken for mosquito bites. Thysanoptera dermatitis is not harmful and will heal in a few days by itself (Leigheb *et al*, 2005). A number of introduced and native thrips already occur in New Zealand.

The potential human health consequences are considered to be extremely low and therefore non-negligible.

9.2.2.5 Risk estimation

The likelihood of entry is considered to be low while the likelihood of exposure is considered to be moderate. The likelihood of establishment is considered to be low with the potential economic consequences considered to be high. The potential environmental consequences are considered to be moderate while the potential human health consequences are considered to be extremely low. *As a result the risk estimate for* Scirtothrips dorsalis *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

9.2.2.6 Assessment of uncertainty

The distribution of *S. dorsalis* throughout China and the presence on grape bunches are uncertain. There is no record on the distances travelled by this thrips. Moreover, there are no references for the lethal lower temperature threshold of this thrips, resulting in uncertainty in the possibility of establishment in New Zealand. Also no records were found on the way standard harvest practices might affect the presence of the life stages of this thrips on grape bunches.

9.2.3 Risk management

9.2.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. The current distribution of *S. dorsalis* in China is unknown. Pest free area status may be an option for table grapes exported from some provinces. Under appropriate conditions a pest free area or a pest free place of production declaration is considered an effective phytosanitary measure against *S. dorsalis*.

Pre-export phytosanitary visual inspection

The thrips are not readily detected because of their extremely small size. Fruit should be inspected closely with a 10x hand lens. The first instar larva is about 0.3 mm long at hatch, transparent in colour, while the adult *S. dorsalis* is pale yellow with darker wings and it is about 0.8 mm in length. Pre-export phytosanitary visual inspection will assist in reducing the likelihood of entry but is not considered to be sufficient as a single viable phytosanitary measure.

Bagging

The different live stages of *S. dorsalis* are very small. The bagging of fruit is not expected to protect it from *S. dorsalis*. Bagging is currently not considered an option.

Heat treatment

At 33°C almost all eggs hatch, all larvae survive to adulthood, while all adult females survived after 10 days. At 34.5°C almost all eggs hatched, but all larvae died, while all adult females survived. In contrast, at 36°C no eggs hatched, all larvae tested died within 5 days and all adult females died within 3 days (Tatara, 1994). This temperature dependent developmental test was performed with only a limited number of individuals (minimum 3, maximum 17). These results indicate that heat treatment could be a viable option against *S. dorsalis*. If evidence is provided of the efficacy of heat treatment in a large-scale test against *S. dorsalis* on table grapes, then this treatment could become a viable option. Currently this is not considered a viable option.

Cold treatment and sulphur dioxide fumigation

Treatment of *S. dorsalis* for 5 hours at -1°C or -2°C did not result in mortality in larvae or adults, nor did a cold treatment for 24 hours. A treatment at -5°C for 5 hours resulted in 16.7% mortality for the larvae and 13.3% for the adult (Tatara, 1994). These results indicate that *S. dorsalis* has a degree of cold sensitivity. A longer cold treatment (for instance in-transit) might be a viable option. Grape bunches can stand limited cold treatments, with the stem freezing near -1°C and the berries near -2°C (Zoffoli, 2008). Cold treatment of the onion thrips *Thrips tabaci* for 6 weeks at 0–1°C resulted in 0.2% survival (275–915 thrips tested) (Yokoyama and Miller, 2000). A treatment of a related thrips (*Frankliniella occidentalis*) on strawberry for 4 weeks at -2 resulted in 100% mortality (Williams, 2005). A treatment of *F. occidentalis* for one week at 04–1.7°C combined with a slow release sulphur dioxide pad resulted in 100% mortality (1698 thrips tested) (Yokoyama *et al*, 2001). Treatment of *S. dorsalis* at low temperatures with a sulphur dioxide pad could have similar effect, although the effectiveness of this treatment needs to be proven. If evidence is provided of the efficacy of cold treatment with or without sulphur dioxide treatment in a large-scale test against *S. dorsalis* on table grapes, then this treatment could become a viable option. Currently this is not considered a viable option.

Methyl bromide fumigation

The Plant Protection and Quarantine Department of the USDA uses methyl bromide fumigation as a measure against *S. dorsalis* on asparagus from Thailand.

Table 22. Treatment T101-b-1-1

Temperature (ºC)	Rate (g/m³)	Minimum Concentration Readings (g/m3) at:	
		0.5 hr	2 hrs
26.67ºC or above	40	32	24
21.11 to 26.11ºC	48	38	29
15.56 to 20.56ºC	64	48	38

The Plant Protection and Quarantine Department of the USDA currently recommends one of following methyl bromide treatments against hitchhikers and surface pests such as thrips on grapes (TQAU USDA, 2008):

Table 23. Treatment T104-a-1

Temperature (ºC)	Rate (g/m³)	Minimum Concentration Readings (g/m3) at:	
		0.5 hr	2 hrs
26.67ºC or above	24	19	14
21.11 to 26.11ºC	32	26	19
15.56 to 20.56ºC	40	32	24
10 to 15ºC	48	38	29
4.44 to 9.44ºC	64	48	38

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, the treatment must kill 99.9968% of the pests in a test of at least 100 000 individual pests. No treatment efficacy level is provided for these specific treatments. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *S. dorsalis* or if evidence is provided of the efficacy against *S. dorsalis* on table grapes, then methyl bromide fumigation is considered a viable option.

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10 Risk assessment of potential hazards – mites

10.1 *Brevipalpus lewisi* – citrus flat mite

Scientific name: *Brevipalpus lewisi* McGregor, 1949 (Acari: Tenuipalpidae)
Other relevant scientific name: *Hystripalpus lewisi*
Common name: citrus flat mite

10.1.1 Hazard identification

10.1.1.1 New Zealand status

B. lewisi is not known to be present in New Zealand. Not recorded in: Ramsay (1980), Manson (1987), PPIN (2009) (accessed 13/02/2009).

10.1.1.2 Biology

B. lewisi reproduces via the production of females from unfertilised eggs, males from fertilised eggs (biology is according to review by Childers *et al*, 2003, unless stated otherwise). In some species of *Brevipalpus* males are rarely found.

Between each active stage is a quiescent developmental stage that is sessile but physiologically active. Adults are morphologically different from the immature stages. Four generations are observed in Spain (Rodriguez *et al*, 1987).

The duration of juvenile development ranges from 16.8 days (34°C) to 31.5 days (22°C). At both 22°C and 28°C the development was faster at high relative humidity (Buchanan *et al*, 1980). Most deaths during juvenile development were due to failure of newly hatched larvae to settle and commence feeding. The population can be composed of entirely females. The adult is extremely small, barely visible to the naked eye: the body length has been recorded as ranging between 0.2 and 0.3 mm in CPC (2007), and as about 0.1 mm in Kearns and others (2001). After a pre-oviposition period of 2.4 days (34°C) to 4.3 days (22°C), adult mites laid up to 3 eggs per mite per day with an average of 0.5 eggs per mite per day (Buchanan *et al*, 1980). The eggs are spherical, extremely small and reddish in colour. They are typically deposited on the fruit and leaves (Kerns *et al*, 2001; accessed 03/04/2009).

In Australia (Victoria) populations increased about 60-fold during one grape season to a maximum of 11 000 mites per grapevine (Buchanan *et al*, 1980). The average number of adult mites present on a bunch increased from 46 at flowering to 1489 at harvest (Buchanan *et al*, 1980). The life cycle consists of four active stages (larvae, protonymph, deutonymph and adult). Adults are the most active stage (Buchanan *et al*, 1980).

Brevipalpus mites inject toxic saliva into fruits, leaves, stems, twigs and bud tissues. *B. lewisi* feeding on grapes (*Vitis vinifera* L.) causes superficial scarring of bunch and berry stems (Buchanan *et al*, 1980). Walnut leaves had the highest mite population in the southeast quadrant of the tree canopy (seen in California). Feeding injury resulted in a coppery appearance with little or no webbing. Defoliation was noticeable and large numbers of exuviae were present on the dropped leaves. In California, *B. lewisi* was most abundant in late July and early August, despite temperatures that averaged 40°C. Peak populations occur during the warmest months, periods of high temperature and low humidity have no deleterious influence upon the mite populations (CPC, 2007).

The mites caused significant russeting and cracking of the rind on pomegranate fruit, with 50–90% damage. *Brevipalpus* mites prefer areas on citrus fruit previously damaged by wind scarring, disease or insect feeding injuries. Mite feeding on citrus causes silvering of tissues. Similar feeding injuries are reported on pistachios. The areas ultimately develop scars. Pathogen-mite feeding interactions are a possibility and extra studies are needed to verify this.

B. lewisi overwinters on grapevines, in the soil litter and between bark crevices. It begins to emerge when the temperature reaches 20°C (Rodriguez *et al*, 1987). In spring the mites feed on all green tissue and cause superficial scarring of bunched fruit and berry stems. Continual feeding results in the tissue withering and becoming dry.

Brevipalpus mites vector a group of viruses classified as unassigned Rhabdoviriidae. No studies have been done on the potential of *B. lewisi* as a vector.

10.1.1.3 Hosts

B. lewisi is polyphagous. It is present on among others on *Citrus* species, grapes, walnuts, forest and ornamental trees and flowering plants (CPC, 2007; Kerns *et al*, 2001).

10.1.1.4 Plant parts affected

B. lewisi is found on the fruit, although they can also be found on the leaves (Kerns *et al*, 2001; Elmer and Jeppson, 1956).

10.1.1.5 Geographic distribution

B. lewisi has been reported from Asia (China, among others (Papademetriou and Dent, 2000)), Europe, Australia (Buchanan *et al*, 1980) and the USA (where it is widespread) (CPC, 2007; Kerns *et al*, 2001).

10.1.1.6 Hazard identification conclusion

B. lewisi has been recorded on grapevine, and is associated with grape berries. It is present in China and is not known to be present in New Zealand. Therefore, *B. lewisi* is considered to be a potential hazard.

10.1.2 Risk assessment

10.1.2.1 Entry assessment

B. lewisi eggs are laid on fruit and leaves and adults feed on fruit. The mites are not readily detected because of their coloration, small size, sluggish behaviour, because they are often hidden on the host plant and because symptoms usually appear only when populations become large (Childers *et al*, 2003; Navia and Mendonca, 2005). The adults measure about 0.1 mm to 0.3mm in length (Kerns *et al*, 2001; CPC, 2007) and can be present in high numbers (up to 1489) on bunches of grapes at harvest (Buchanan *et al*, 1980).

Given that:

- all life stages occur on the fruit of grapevine;
- the life stages are small, often hidden, and not readily visible unless populations are large;
- *B. lewisi* can be present in high numbers on grape bunches at harvest;

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

10.1.2.2 Exposure assessment

Pedicels, peduncle and uneaten berries of imported grapes will be thrown away. If these are thrown in compost heaps or on the side of the road, *B. lewisi* adults could spread to plants in the vicinity. Adults are mainly responsible for dispersal to new growth (Buchanan *et al*, 1980). The distance they disperse is currently unknown. Most deaths during juvenile development were due to failure of newly hatched larvae to settle and commence feeding (Childers *et al*, 2003). *B. lewisi* is polyphagous and hosts such as citrus and amenity species occur widely in suburban areas and domestic gardens in New Zealand.

Given that:

- uneaten fruit that carries life stages of *B. lewisii* may be discarded in compost heaps or the environment;
- juveniles might complete their development to adults on discarded grapes;
- adults and possibly juveniles might disperse to other nearby plants;
- *B. lewisi* is polyphagous, and acceptable hosts are widely available in suburban areas and domestic gardens;

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

10.1.2.3 Establishment assessment

B. lewisi is found in areas that are drier than the tropical to subtropical distributions for several other *Brevipalus* species (Childers *et al*, 2003). Peak populations occur during the warmest months in California but its global distribution suggests that the New Zealand climate would not prevent its establishment, at least in the warmer parts of the North Island. *B. lewisi* reproduces via the production of females from unfertilised eggs, males from fertilised eggs, therefore one female could be enough to establish a population. In Australia (Victoria) populations increased about 60-fold during one grape season to a maximum of 11 000 mites per grapevine. *B. lewisi* is polyphagous and hosts such as citrus and amenity species, as well as domestic and commercial grapevines, occur widely in modified environments New Zealand.

Given that:

- a single female can establish a population;
- *B. lewisi* is polyphagous, and acceptable hosts are widely available in modified environments in New Zealand;
- at least parts of New Zealand have a climate suitable for *B. lewisi*;

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

10.1.2.4 Consequence assessment

Economic consequences

B. lewisi is often an economically important pest of citrus (Kerns *et al*, 2001). There are reports of up to 25% of fruit in lemon orchards not being marketable and 50–90% of pomegranates being damaged by *B. lewisi*. On grapes in Bulgaria up to 30% loss in yield has been reported (Raikov and Nachev, 1965; cited in Goodwin, 1982). Therefore, *B. lewisi* could lower productivity for a number of crops. It could also complicate pest control programmes in vineyards, citrus orchards and perhaps other fruit crops. The establishment of *B. lewisi* could also have an effect on access to some markets. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- damage by *B. lewisi* would decrease productivity of several commercial crops, including grapes and citrus, if not controlled;
- controlling *B. lewisi* could increase pest control costs for industries such as grapes and citrus in New Zealand;
- access to some markets could be affected;

The potential economic consequences are considered to be moderate and therefore non-negligible.

Environmental consequences

Environmental consequences include damage to amenity plants. Most exotic pests that attack native plants are polyphagous, but highly damaging polyphagous species appear exceptional and it has been postulated that the impact of relatively specialised organisms is likely to be greater than highly polyphagous species (Beever *et al*, 2007). *B. lewisi* is a pest of forest and ornamental trees such as *Alnus*, *Catalpa*, *Melia*, *Myrtus* and *Pittosporum*, some of which have representatives in New Zealand.

Given that:

- *B. lewisi*, which is polyphagous, is a pest of forest and ornamental trees that are grown in New Zealand;
- *B. lewisi* could attack native plants but is unlikely to be highly damaging to these species;

The potential environmental consequences are considered to be low to moderate and therefore non-negligible.

Human health consequences

Mites are commonly reported to cause respiratory allergy. However, the establishment of additional mite species would be unlikely to cause any further impact on human health, unless total mite populations were to increase very significantly.

10.1.2.5 Risk estimation

The likelihood of entry is considered to be high. The likelihood of exposure is considered to be moderate. The likelihood of establishment is considered to be high. The potential economic consequences are considered to be moderate and environmental consequences are considered to be low to moderate. *As a result the risk estimate for* Brevipalpus lewisi *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

10.1.2.6 Assessment of uncertainty

The ability of the different life stages to survive during transit and the dispersal capacity of the different life stages are uncertain. The extent and ability of *B. lewisi* to infest native plants is unclear.

10.1.3 Risk management

10.1.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. The current distribution of *B. lewisi* in China is unknown. Pest free area status may be an option for table grapes exported from some provinces. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *B. lewisi*.

Pre-export phytosanitary visual inspection

The mites are not readily detected because of their coloration and extremely small size. Fruit should be inspected closely with a 10x hand lens. The mites are not readily detected because of their coloration, small size, sluggish behaviour, because they are often hidden on the host plant and because symptoms usually appear only when populations become large. Pre-export phytosanitary visual inspection will assist in reducing the likelihood of entry but is not considered to be sufficient as a single viable phytosanitary measure.

Bagging

The different life stages of *B. lewisi* are very small. The bagging of fruit is not expected to protect it from *B. lewisi*. Bagging is currently not considered an option.

Methyl bromide fumigation followed by cold treatment

The Plant Protection and Quarantine Department of the USDA currently recommends one of the following three methyl bromide treatments against *B. chiliensis* on grapes (TQAU USDA, 2008):

Table 24. Treatment T108-a-1

Temperature (°C)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
21.11 °C or above	32	25	18
Followed by a cold treatment:			
Temperature (°C)	Exposure period		
0.56 to 2.77°C	4 days		
3.33 to 8.33°C	11 days		

Table 25. Treatment T108-a-2

Temperature (°C)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:		
		0.5 hr	2 hrs	2.5 hrs
21.11 °C or above	32	25	18	18
Followed by a cold treatment:				
Temperature (°C)	Exposure period			
1.11 to 4.44°C	4 days			
5 to 8.33°C	6 days			
8.88 to 13.33°C	10 days			

Table 26. Treatment T108-a-3

Temperature (°C)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:			
		0.5 hr	2 hrs	2.5 hrs	3 hrs
21.11 °C or above	32	25	18	18	17
Followed by a cold treatment:					
Temperature (°C)	Exposure period				
6.11 to 8.33°C	3 days				
8.88 to 13.33°C	6 days				

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, the treatment must kill 99.9968% of the pests in a test of at least 100 000 individual pests. This treatment schedule is described as being suitable for tarpaulin or chamber fumigations however no treatment efficacy level is provided. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *B. lewisi* or if evidence is provided of the efficacy against *B. lewisi* on table grapes, then cold treatment followed by methyl bromide fumigation is considered a viable option.

Methyl bromide fumigation

Methyl bromide fumigation is a quarantine treatment for grapes from Chile to Australia and the USA (CPC, 2007). The assumption is made that a methyl bromide treatment effective against the related *Brevipalpus chiliensis* will also be effective against *B. lewisi.*

Biosecurity Australia currently recommends one of following methyl bromide treatments against *B. chiliensis* on grapes from Chile for Australia (Biosecurity Australia, 2005):

Fumigation with methyl bromide must be carried out for a duration of 2 hours according to the specifications below:

- 32g/m^3 at a grape pulp temperature of 21^{o}C or greater;
- 40g/m^3 at a grape pulp temperature of 16 ^{o}C or greater but less than 21 ^{o}C;
- 48g/m^3 at a grape pulp temperature of 10 ^{o}C or greater but less than 16 ^{o}C.

The loading ratio should not exceed 80% of the chamber volume. Fruit is not to be fumigated on the grape pulp temperature is less than 10 ^{o}C.

In the USA, the following treatment is used for external feeders on grapes from Chile. This is identical to the treatment used in the USA on grapes from other countries for insects other than *Ceratitis capitata* and *Lobesia botrana*) (TQAU USDA, 2008). It is essentially the same as the treatment recommended by Biosecurity Australia for *B. chiliensis* on grapes from Chile, with an additional treatment option at temperatures below 10^{o}C.

Table 27. Treatment T101-i-2-1 MB at NAP – tarpaulin or chamber

Temperature (^{o}C)	Rate (g/m^3)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
26.7 ^{o}C or above	24	19	14
21.1–26.1 ^{o}C	32	26	19
15.6–20.6 ^{o}C	40	32	24
10–15 ^{o}C	48	38	29
4.4–9.4 ^{o}C	64	48	38

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, the treatment must 99.9968% of the pests in a test of at least 100 000 individual pests.

No treatment efficacy level is provided for this specific treatment, either by USDA or Biosecurity Australia. If the efficacy of this treatment is accepted as being effective against *B. lewisi* or if evidence is provided of the efficacy against *B. lewisi* on table grapes, then methyl bromide fumigation is considered a viable option.

10.2 *Tetranychus kanzawai* – kanzawa spider mite

Scientific name: *Tetranychus kanzawai* Kishida, 1927 (Acarina: Tetranychidae)
Other relevant scientific names: *Tetranychus hydrangeae* Pritchard & Baker
Common name: kanzawa spider mite

10.2.1 Hazard identification

10.2.1.1 New Zealand status

Tetranychus kanzawai is not known to be present in New Zealand. Not recorded in: Manson (1987), Migeon and Dorkeld (2006), PPIN (2009) (accessed 19/02/2009).

10.2.1.2 Biology

T. kanzawai is one of the most common spider mites in the entire East Asian region (Takafuji and Hinomoto, 2008). Unfertilised eggs develop into males, while fertilised eggs develop into females (Shih, 1979). The proportion of females in a population averaged between 0.76 and 0.83. The sex ratio is determined by the genotype and age of the mother (Takafuji and Ishii, 1989; Shih, 1979). Some overwintering populations consist of 100% females (Takafuji *et al*, 2007). In Fuzhou, China, populations of *T. kanzawai* on strawberries peaked in late December and mid-February and reached outbreak proportions at the end of the growing season (CPC, 2007). Females tend to oviposit in a localised area, with most of the eggs produced during a peak period of a few days after a preoviposition period (Shih, 1979).

The completion of a life cycle in the laboratory required 5.7 days at 27°C. The average generation time was 15.4 days and developmental stages took 5.0 days. The preoviposition period was 0.9 days. The intrinsic rate of increase is 0.39, while the net reproductive rate is 44.6 (Shih *et al*, 1978).

At 35°C and 60% relative humidity the generation time was 6.2 days. The average number of eggs laid was 7.2 while the oviposition period was 9.7 days. At 15°C and 80% RH the mites have a generation time of 27.5 days and the mean number of eggs laid per day was 2.0, while the oviposition period was 28.4 days. The optimal developmental temperature is considered to be between 25°C and 30°C (HuaGuo *et al*, 1998). Developmental times at different temperatures are depicted in Table 28.

Table 28. Development time in days for life stages of *Tetranychus kanzawai* at various temperatures.

Period:	15°C	20°C	25°C	30°C
Egg	15.1	8.9	4.4	2.3
Larval	6.4	3.5	1.9	1.2
Protonymphal	5.6	2.8	1.7	1.0
Female lifespan	33.3	16.8	15.5	13.4
Eggs laid per female	37.5	59.4	100.6	103.3
Intrinsic rates of increase	0.062	0.134	0.252	0.371

The developmental threshold temperatures for the egg, protonymphal and deutonymphal stages were 13.9, 12.6 and 12.6°C, respectively, and the corresponding temperature sums for development 39.2, 21.4 and 18.2 day-degrees C (CPC, 2007).

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 (CPC, 2007). Geographic variation in diapause capacity among populations of *T. kanzawai* has been observed. A study of populations from various regions in East and Southeast Asia found that this was complicated and not simply attributed to latitudinal differences. A trend for a decrease in diapause expression with increasing temperature was noted, but *T. kanzawai* did not show any clear clinal decrease in diapause capacity with some populations from the tropics maintaining a high capacity for diapause (Takafuji and Hinomoto, 2008).

On hydrangea (*Hydrangea macrophylla*) in Japan two different seasonal population trends occur: one with a single peak occurrence between May and June, and the other with a spring peak in June and an autumn peak in September-October. Each year the populations declined abruptly just after the spring peak, possibly due to the change in secondary compounds in plants (CPC, 2007). Studies on strawberry gardens 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. In addition to predator avoidance *T. kanzawai* uses the webs as a place for secretions. It secretes pellets that repel predators on leaf surfaces (Oku, 2008). In the presence of a predator, a significantly greater proportion of *T. kanzawai* females entered the quiescent stage on webs than on leaves. Furthermore, significantly more females survived on webs than on leaves. In contrast, significantly fewer males guard females on webs, resulting in less opportunity to mate (Oku *et al*, 2003). The positive correlation between leaf hair traits (hair height and hair density) and host plant acceptance by *T. kanzawai* suggests that leaf hairs provide a refuge from predators for the females (Oku *et al*, 2006). Experiments have shown that beans are a better host than grapes, but *T. kanzawai* can adapt to grapes (Kondo *et al*, 1987).

T. kanzawai was found in very low numbers in vineyards in Taiwan, where *Tetranychus urticae* Koch was the major spider mite found. *T. kanzawai* were found on grape clusters in eight out of ten surveyed vineyards. Ten percent of grape clusters were infested, but the density was low, with only 0.63 mites per cluster. The percentage of grape berries infested with mites was 0.4%. Experimental inoculation of unripe berries with *T. kanzawai* resulted in the mites either dying before development into the next instar or running away. Inoculating ripe berries lead to mites being able to feed, develop and reproduce (Ho and Chen, 1994). The population density varied considerably between grape cultivars (Ashihara, 1996) as did developmental success. High developmental success was observed on Muscat Bailey A, one quarter of the larvae developed to adults on Kychou, 2% developed on Muscat of Alexandria, while no developmental success was observed on Neo Muscat (Ashihara, 1996).

10.2.1.3 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), *Solanum melongena* (aubergine), *Vitis vinifera* (grapevine; CPC, 2007).

10.2.1.4 Plant parts affected

Leaves, stems, fruit (CPC, 2007; Ashihara, 1996; Ho and Chen, 1994).

10.2.1.5 Geographic distribution

Africa, Australia, USA, China, India, Malaysia, Japan, Thailand, Taiwan, Vietnam, Korea, Greece. (Migeon and Dorkeld, 2006; Takafuji and Hinomoto, 2008)

10.2.1.6 Hazard identification conclusion

Tetranychus kanzawai has been recorded on grapes, and is associated with grapes. 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.

10.2.2 Risk assessment

10.2.2.1 Entry assessment

T. kanzawai can feed, develop and reproduce on ripe grape berries (Ho and Chen, 1994). 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. In contrast, in a survey of grapes in Taiwan, 10% of grape clusters were infested with a low density of mites per cluster. The small size of the organism and the possibility of low levels of infestation make it possible that they will be missed by a standard grading and packing process. The population density varied considerably between grape cultivars (Ashihara, 1996), with some cultivars showing high developmental success. *Tetranychus* species are regularly intercepted at the border in New Zealand and other countries (Brake *et al*, 2003; MAFBNZ, 2009). Females tend to oviposit in localised areas, with most of the eggs produced during a peak period of a few days.

Given that:

- *T. kanzawai* can occur on ripe grape berries;
- the small size of the mites means that a standard grading and packing process could miss them if infestation levels are low;
- *Tetranychus* species are regularly intercepted at the New Zealand border;

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

10.2.2.2 Exposure assessment

Pedicels, peduncle and uneaten berries will be thrown away. If these are thrown in compost heaps, it is assumed that adults would be able to move off the discarded grapes and infest nearby hosts. *T. kanzawai* has 160 known hosts (Migeon and Dorkeld, 2006). Major hosts are citrus, strawberry, peach and grapevine, which are found throughout New Zealand.

Given that:

- uneaten fruit that carries the mite may be discarded in compost heaps or the environment;
- juveniles might complete their development to adults on discarded grapes;
- adults and possibly juveniles might disperse to other nearby plants;
- *T. kanzawai* is polyphagous, and acceptable hosts are likely to be available nearby;

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

10.2.2.3 Establishment assessment

T. kanzawai has a reproduction, in which unfertilised eggs develop into males and fertilised eggs develop into females. With this form of reproduction it is quite usual for unfertilised females to mate with their male offspring. Arrhenotokous parthenogenesis could provide the necessary males, but only if the female does not disperse and stays alive long enough for the eggs to hatch and the male offspring to develop to full adulthood. Then they need to locate that same single female. When there is only one female present, the likelihood of this occurring 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. Some overwintering populations consist of 100% females. The optimal developmental temperature for *T. kanzawai* is between 25°C and 30°C (HuaGuo *et al*, 1998). The developmental threshold temperatures for the egg, protonymphal and deutonymphal stages were 13.9, 12.6 and 12.6°C, respectively. *T. kanzawai* expressed more than 90% diapause at 15°C in four main islands of Japan. This could enhance the capability of *T. kanzawai* to survive winter. The intrinsic rate of increase at 15°C is 0.062. This indicates that the temperature in most parts of New Zealand will be less than optimal. The most suitable regions will be in the northern, warmer parts of New Zealand.

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;
- parts of New Zealand, particularly the warmer northern regions will have a suitable climate for *T. kanzawai*;

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

10.2.2.4 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 and extra control measures needed, establishment could also affect the export of certain commodities to other countries. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- damage by *T. kanzawai* would decrease productivity of several commercial crops, including grapes, citrus and stonefruit, if not controlled;
- controlling *T. kanzawai* could increase pest control costs for industries such as grapes, citrus and stonefruit in New Zealand;
- access to some markets could be affected;

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*, which is in the same genus as blackberry), and *Acaena* (for example *A. anserinifolia*, bidibids), 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). While both families have lots of native representatives, *Sophora*, *Rubus* and *Acaena* are the most likely to be regularly encountered. Most exotic pests that attack native plants are polyphagous, but highly damaging polyphagous species appear exceptional and it has been postulated that the impact of relatively specialised organisms is likely to be greater than highly polyphagous species (Beever *et al*, 2007).

Given that:

- *T. kanzawai*, which is polyphagous, could attack garden and amenity plants that are grown in New Zealand;
- *T. kanzawai* could attack native plants but is unlikely to be highly damaging to these species;

The potential environmental consequences are considered to be low to moderate and therefore non-negligible.

Human health consequences

No human health consequences directly related to *T. kanzawai* are known. Although mites are commonly reported to cause respiratory allergy, the mites responsible are rarely spider mites and belong to completely different mite families. However, spider mites can cause allergic symptoms in laboratory workers who study them. Nevertheless, the establishment of additional mite species would be unlikely to cause any further impact on human health, unless total mite populations were to increase very significantly.

10.2.2.5 Risk estimation

The likelihood of entry is considered to be moderate to high, 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 potential environmental consequences are considered to be 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.*

10.2.2.6 Assessment of uncertainty

The degree of damage by this organism to grape bunches in China is uncertain. Also the effect of average New Zealand temperatures on this organism is unclear. Little information is available on the mobility of the mites.

10.2.3 Risk management

10.2.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. The current distribution of *T. kanzawai* in China is unknown; therefore pest free area status may be an option for table grapes exported from some provinces. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *T. kanzawai*.

Cold treatment followed by methyl bromide fumigation

At low temperatures, *T. kanzawai* can go into diapause. The USA uses cold treatment combined with methyl bromide treatment for *T. kanzawai* on apples from Japan and Korea (TQAU USDA, 2008). The treatment depends on container type (plastic or cardboard):

Table 29. Treatment T109-a-1 – cold treatment followed by methyl bromide fumigation (plastic bins)

Temperature (ºC)		Exposure period	
1.11ºC or below		40 days	
Followed by methyl bromide fumigation:			
Temperature (ºC)	Rate (g/m³)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
10 ºC or above	48	44	36

Table 30. Treatment T109-a-2 – cold treatment followed by methyl bromide fumigation (cardboard bins)

Temperature (ºC)		Exposure period	
1.11ºC or below		40 days	
Followed by methyl bromide fumigation:			
Temperature (ºC)	Rate (g/m³)	Minimum concentration readings (g/m3) at:	
		0.5 hr	2 hrs
15 ºC or above	38	35	29

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, the treatment must 99.9968% of the pests in a test of at least 100 000 individual pests. No treatment efficacy level is provided for this specific treatment. If the efficacy of this treatment as stated by the USDA is accepted as being effective against *T. kanzawai* or if evidence is provided of the efficacy against *T. kanzawai* on table grapes, then cold treatment combined with methyl bromide fumigation is considered a viable option.

Methyl bromide fumigation

The USDA recommends several treatment options for spider mites on imported fresh commodities.

For external feeders on grapes from Chile the following treatment is used (this is identical to the treatment used on grapes from other countries for insects other than *Ceratitis capitata* and *Lobesia botrana*) (TQAU USDA, 2008):

Table 31. Treatment T101-i-2-1 MB at NAP – tarpaulin or chamber

Temperature (ºC)	Rate (g/m³)	Minimum Concentration Readings (g/m3) at:	
		0.5 hr	2 hrs
26.7 ºC or above	24	19	14
21.1–26.1 ºC	32	26	19
15.6–20.6 ºC	40	32	24
10–15 ºC	48	38	29
4.4–9.4 ºC	64	48	38

The United States has required that the efficacy of commodity treatments for certain pests meets or exceeds a Probit 9 statistical standard. To meet this standard, the treatment must 99.9968% of the pests in a test of at least 100 000 individual pests. No treatment efficacy level is provided for this specific treatment. If the efficacy of this treatment as stated by the

USDA is accepted as being effective against *T. kanzawai* or if evidence is provided of the efficacy against *T. kanzawai* on table grapes, then methyl bromide fumigation is considered a viable option.

Hot water immersion

Hot water immersion appears to be a potentially useful disinfestation method for *Tetranychus urticae* on persimmons. The time needed for effective treatment by hot water immersion was not reduced by subsequent cool storage at 0°C for up to eight weeks. Rather, cool storage had the effect of keeping mites alive, relative to LT_{99} estimates calculated for mites stored at 20°C (Lester *et al*, 1997). Adding an organosilicone surfactant like Silwet L-77 could enhance this wet treatment. A treatment with 5% Silwet L-77 killed 99.5% of *T. urticae* eggs (401 eggs tested) and 96.7% of adults and immatures (722 adults and immatures tested). Interestingly, at 0.25% Silwet L-77, 99.0% of adults and immatures were killed (702 tested) while 100% of eggs were killed (295 eggs tested) (Tipping *et al*, 2003). Efficacy of hot water immersions can also be increased when the dips are done in combination with mechanical removal methods, such as pressurised sprays and roller brushes (Hansen *et al*, 2006). The effectiveness of hot water immersion treatment combined with surfactant (and possibly mechanical removal) against *T. kanzawai* on grapes needs to be confirmed in a large-scale commercial trial. Therefore, this treatment is currently not considered a viable option.

Cold treatment with sulphur dioxide fumigation

T. kanzawai has a strong diapause capacity. Therefore cold treatment alone is unlikely to be sufficient. Two related mites (*Tetranychus pacificus* and *Tetranychus urticae*) were tested in experiments at low temperature (0.4–1.7°C) combined with slow release sulphur dioxide pads. After 2 weeks 57.1% of *T. pacificus* had died, increasing to 98.0% mortality after 6 weeks (28 782 mites tested). For *T. urticae*, after 2 weeks 80.0% mortality was seen, increasing to 99.6% after 6 weeks (10 965 mites tested). The insects were tested in plastic cups. A large scale test with insects on grape bunches resulted in 100% mortality after 8 weeks for *T. urticae* and 99.7% mortality for *T. pacificus* (Yokoyama *et al*, 2001). A combined cold and SO_2 treatment is expected to have similar effects on *T. kanzawai*. Until efficacy on table grapes against *T. kanzawai* is provided, this combined treatment is not considered a viable option.

Pre-export phytosanitary visual inspection

The mites are not readily detected because of their extremely small size. The presence of webbing could give an indication of their presence. Pre-export phytosanitary visual inspection will assist in reducing the likelihood of entry but is not considered to be sufficient as a single viable phytosanitary measure.

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11 Risk assessment of potential hazards – Fungi

11.1 *Alternaria viticola*

Scientific name (anamorphic): *Alternaria viticola* (Pleosporales: Pleosporaceae)
Other relevant scientific names: None known (Mycobank 2009)
Common name: Spike-stalk brown spot of grape

11.1.1 Hazard identification

11.1.1.1 New Zealand status

Not known to be present in New Zealand. Not recorded in: Landcare Research (2009), PPIN (2009).

11.1.1.2 Biology

A. viticola is a fungal pathogen that mainly attacks young, tender stalks of *V. vinifera*. The initial infections are on the pre-blooming stage of an inflorescence, and infection continues until flowering ends. In China, symptoms of infection normally occur during late May and June. Wounds favour infection, but are not absolutely necessary, as the pathogen can invade through natural openings. The optimum temperature for conidiospore germination is 25–27ºC (Liu *et al*, 1996; Ma *et al*, 2004). *A. viticola* is capable of infecting grapes (AQSIQ, 2007).

11.1.1.3 Transmission

A. viticola is transmitted via conidia that have overwintered on tendrils, branches, in bud scales or diseased debris. Conidia can be spread via wind and rain (Ma *et al*, 2004).

11.1.1.4 Hosts

Only one host has been recorded in the literature, *V. vinifera* (Liu, 1996; Ma *et al*, 2004; AQSIQ, 2007).

11.1.1.5 Geographic distribution

A. viticola was originally described from France. It has been recorded from China (Liu *et al*, 1996; Ma *et al*, 2004; AQSIQ, 2007).

11.1.1.6 Hazard identification conclusion

Alternaria viticola has been recorded on grapevine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *A. viticola* is considered to be a potential hazard.

11.1.2 Risk assessment

11.1.2.1 Entry assessment

A. viticola could enter New Zealand on symptomatic young, undeveloped berries, on the peduncle or woody tissue or as spores on asymptomatic table grapes. Symptomatic fruit is likely to be identified at the harvesting stage and would probably not be exported, and is therefore an unlikely means of entry. Immature, infected berries may be present in a cluster of mature, uninfected berries when berry development is uneven across a cluster. Moreover, the pathogen may be transmitted as spores on asymptomatic grapes.

Given that:

- symptomatic grapes are likely to be detected at harvest;
- uneven development could give rise to infected immature berries;
- spores could be present on asymptomatic grapes;

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

11.1.2.2 Exposure assessment

A. viticola can be transmitted via conidia on uninfected mature grapes, on symptomatic young, undeveloped berries, on the peduncle or woody tissue or as spores on asymptomatic table grapes. However, without fungal infection, growth and reproduction, it is likely that there would be insufficient conidia on uninfected grapes for a reasonable chance of transmission. Therefore this is not considered a viable means of exposure.

A. viticola-infected young, undeveloped berries, peduncle or woody tissue could be discarded in rubbish bins or compost and could act as a source of diseased debris. Conidia can be spread by wind and rain. Birds feed on discarded grapes and can spread *A. vinifera* by removing infected berries from the compost.

V. vinifera is the only known potential host species present in New Zealand. *V. vinifera* is widely distributed and is sometimes grown in home gardens where it is likely to be close to compost heaps or domestic rubbish bins.

Given that:

- conidia on uninfected grapes are unlikely to have enough disease pressure;
- infected young berries, peduncle and woody tissue can act as a source of diseased debris;
- *V. vinifera* is the only known host;

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

11.1.2.3 Establishment assessment

The current geographical distribution of *A. viticola* is limited to China and no information is available regarding the climatic or temperature tolerances of *A. viticola*. However, many other *Alternaria* spp. are present and established in New Zealand. *V. vinifera* is present in New Zealand and the pathogen does not require a vector to spread. Given the limited information on *A. viticola*, it is difficult to estimate the likelihood of establishment, but establishment cannot be excluded.

Given that:

- the current distribution is limited to China;
- limited information on *A. viticola*;

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

11.1.2.4 Consequence assessment

Economic consequences

A. viticola is a pathogen of *V. vinifera*, which is a species of economic importance to New Zealand. Control measures would themselves impose an economic cost. Given the limited information on *A. viticola*, estimating the likely cost of control or eradication (or even if eradication is possible) is difficult. Economic consequences would depend on the final distribution of the pathogen, the level of damage to the host, and the cost of control measures.

Given that:

- *V. vinifera* is a species of economic importance;
- information on damage, control or (possibility of) eradication of *A. viticola* is very limited;

The potential economic consequences are considered to be non-negligible.

Environmental consequences

Environmental consequences are difficult to estimate due to the very limited information on *A. viticola*.

The potential environmental consequences are considered to be non-negligible.

Human health consequences

Human health consequences are difficult to estimate due to the very limited information on *A. viticola*, but fungal plant pathogens do not usually infect humans.

The potential human health consequences are considered to be negligible.

11.1.2.5 Risk estimation

The likelihood of entry and exposure are low. The likelihood of establishment is non-negligible. Establishment of *A. viticola* would result in non-negligible economic and environmental consequences to New Zealand. *As a result the risk estimate for* A. viticola *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

11.1.2.6 Assessment of uncertainty

Information on *A. viticola* is very limited. The assessment that spores on uninfected grapes are not a viable means of exposure depends on the assumption that mature grapes cannot be infected, even when wounded, discarded or attacked by other pathogens. Whether young, undeveloped berries within a cluster of mature berries can be infected or pass on the pathogen is unclear.

11.1.3 Risk management

11.1.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. The current distribution of *A. viticola* in China is unclear; therefore pest freedom status could be a viable option if pest freedom is proven.

In-field control and surveillance

Surveys of export orchard areas would be expected to detect *A. viticola* presence. Any grape bunches with infected berries should not be permitted to be harvested and exported to New Zealand. A specified regime of fungicide application, mandating removal of diseased berries, pedicels and fruit spurs should mitigate the risk of *A. viticola* infection. Currently no information is available on which fungicides are effective against *A. viticola*, but it may be reasonable to assume that fungicides that are effective against other *Alternaria* spp. would be effective. In-field control of *A. viticola* in China is considered an option.

Bagging

The practice of bagging individual fruit is likely to mitigate the spread and landing of spores on the fruit surface. Bagging can only mitigate the risk if the bags are left on the grapes up until harvest. Bagging is considered an option when combined with phytosanitary visual inspection.

Pre-export phytosanitary visual inspection

A. viticola is transmitted via symptomatic young, undeveloped berries, on the peduncle or woody tissue. Infected grape bunches should not be harvested or used for export.

A. viticola could also enter the country via conidia on uninfected mature fruit. However, without fungal infection, growth and reproduction, it is likely that there would be insufficient conidia on uninfected grapes for a reasonable chance of transmission; therefore this is not considered a viable means of exposure. *A. viticola* only infects young berries and does not infect mature berries. Young, undeveloped berries within a cluster of mature berries should be detected during harvest and these grape bunches should not be exported, since young berries can become infected. Pre-export phytosanitary visual inspection is currently considered a viable option when combined with bagging.

11.2 *Pilidiella diplodiella*

Scientific name (anamorphic): *Pilidiella diplodiella* (Speg.) Crous & van Niekerk 2004 (Diaporthales: Schizoparmaceae)

Other relevant scientific names: *Phoma diplodiella* Speg.; *Coniothyrium diplodiella* (Speg.) Sacc.; *Clisosporium diplodiella* (Speg.) Kuntze; *Coniella diplodiella* (Speg.) Petr. & Syd.; *Coniella petrakii* B. Sutton

Common names: White rot of grape, Hail disease

11.2.1 Hazard identification

11.2.1.1 New Zealand status

Pilidiella diplodiella is not known to be present in New Zealand (Balasubramaniam, 1997; Landcare Research, 2009; CPC, 2007).

11.2.1.2 Biology

P. diplodiella is a fungus that infects rachis, pedicels and damaged grapes of *V. vinifera*. Leaf infection has been reported after inoculation but does not appear to occur in the field (Locci and Quaroni, 1972). *P. diplodiella* can directly infect the rachis and pedicel, where it causes “cluster drying-off”, a disease that is often considered a physiological disorder (Bisiach and Viterbo, 1973).

P. diplodiella is unable to directly infect intact grapes (Bisiach and Viterbo, 1973). It can infect damaged grapes and is frequently associated with hail-damaged grapes (Faes *et al*, 1932; David and Rafaila, 1966). Sun scorch, mechanical damage or infection by other pathogens can also damage grapes and provide a route for infection (CPC, 2007). In infected grapes *P. diplodiella* will form pycnidia and discharge large numbers of conidia (~80 000) (Turian, 1954).

High (90–100%) relative humidity (RH) favours infection, and grape bunches close to the ground are more susceptible as the humidity is higher. Vineyards can also be infected if subjected to summer rain followed by persistent high RH and temperature (24–27°C) (Pearson and Goheen, 1988). Conidia germinated at 20–32°C (Rafaila *et al*, 1968). Infection slows below 15°C, and is stopped above 34°C (CPC, 2007).

Once the fungus has infected lesions of damaged grapes, fungicidal control is almost impossible as the period of incubation of the spore is only 12 hours in the lesion, and when the germ-tube has penetrated the flesh it is beyond the reach of fungicides (Turian, 1954). Infections may then spread to the pedicel, which takes at least 48 hours (Faes *et al*, 1932). The fungus can be controlled before this point by removal of damaged grapes, together with 1–2 cm of the pedicel (Faes *et al*, 1932). Certain fungicides can control the fungus if applied within 18 hours of a hailstorm (David and Rafaila, 1966).

In Chinese vineyards, *P. diplodiella* often first occurs in June on clusters lying on the ground. Even low rainfall after several windless nights can induce high RH and heavy dew a few cm above the ground, which gives favourable conditions for infection (Chen *et al*, 1979). Some resistance to *P. diplodiella* exists in cultivars of *Vitis davidii* (Chinese wild grape) and in *V. vinifera* × *V. davidii* hybrids (Xu, 2003), and a programme of marker-assisted breeding is underway to produce resistant cultivars (Wang *et al*, 2003). At this stage whether resistant cultivars would completely block transmission of the pathogen is unclear.

Transmission

P. diplodiella conidia are spread over short distances by rain splashes or by cutting implements. *P. diplodiella* is transmitted as hyphae in infected grapes, rachis, pedicel or as conidia on the surface of grapes or in soil. *P. diplodiella* conidia overwinter in soil and infected residue (Turian, 1954) and are extremely durable, surviving for up to 1–2 years in soil, 2–3 years on grapes (CPC, 2007) and for 11–16 years in dry, cold conditions (CPC, 2007; Faes *et al*, 1932).

11.2.1.3 Hosts

V. vinifera is a major host (CPC, 2007). *P. diplodiella* has also been recorded on *Careya arborea* (kumvi), *Artabotrys hexapetalus* (climbing ilang-ilang) and *Geranium* spp. (geranium) (Shreemali, 1973; Shreemali, 1970; Singh and Sinch, 1966).

11.2.1.4 Geographic distribution

P. diplodiella is present in China (Chen *et al*, 1979; Liu *et al*, 1999). *P. diplodiella* is widespread in grape-growing regions of the world, in Europe, North and South America, across Asia (among others Japan and Korea) and in some countries in Africa. *P. diplodiella* is present in Australia but may be restricted to New South Wales (CPC, 2007).

11.2.1.5 Hazard identification conclusion

Pilidiella diplodiella has been recorded on grapevine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *P. diplodiella* is considered to be a potential hazard.

11.2.2 Risk assessment

11.2.2.1 Entry assessment

P. diplodiella could enter New Zealand as mycelia in infected table grapes or as conidia on table grapes. As infected grapes are likely to be damaged and show signs of infection, and infected rachis are likely to show cluster drying-off, these grapes are likely to be discarded before packing and transport to New Zealand and are considered an unlikely means of entry.

If *P. diplodiella* is controlled in the field by application of fungicides (for example, Bordeaux mixture) after hailstorms, the likelihood of entry may be negligible, but it is not clear if this is standard practice in Chinese viticulture.

The most likely means of entry is via conidia on the surface of uninfected grapes.

Given that:

- infected symptomatic grapes are likely to be discarded before packaging;
- conidia can be present on uninfected grapes;

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

11.2.2.2 Exposure assessment

Fruit that is culled or unsold by wholesalers and retailers is likely to be discarded into a rubbish bin or skip (closed or open) and taken to a landfill. 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. If this waste is thrown in compost heaps or roadside, conidia on the surface of grapes could spread, or could infect uneaten damaged berries and produce more inoculum.

Conidia on discarded pedicels, peduncle or uneaten damaged berries could give rise to a primary infection, which would then give rise to conidia that can spread via wind-driven rain splashes or could remain viable in soil for 1–2 years. Conidia could spread from compost heaps to potential hosts in close proximity (*Vitis* spp. or possibly *Geranium* spp.), or via discarded table grapes that spread inoculum in soil that is later used to grow grapes. Viable conidia would have to survive and spread onto susceptible hosts at a time when they are producing grapes.

The exposure via soil on which grapevine is then grown is considered negligible since conidia are only viable in soil for 1–2 years and newly planted grapevines will take longer than 1–2 years before producing grapes. Conidia could be spread if soil was used as compost for mature grapevines or if birds spread infected grapes.

Given that:

- conidia can spread via wind-driven rain splashed from compost;
- remain viable in soil for 1–2 years, but grapevine doesn't produce grapes the first years;
- the fungus only infects damaged berries, rachis and pedicel but not leaves;

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

11.2.2.3 Establishment assessment

Information on the preferred humidity and temperatures shows that *P. diplodiella* germination and growth is favoured by summer rain followed by persistent high RH and temperature. *P. diplodiella* infection slows down below 15°C. The current geographical distribution of *P. diplodiella* suggests that New Zealand is suitable for establishment.

Given that:

- germination and growth is favoured by high RH and temperature;
- infections slows down below 15°C;

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

11.2.2.4 Consequence assessment

Economic consequences

P. diplodiella is a significant pathogen of *V. vinifera* and also infects *Geranium* spp. but usually requires specific conditions for infection. Control measures are available, but would increase the economic cost. *P. diplodiella* is most damaging on already damaged grapes, so economic consequences may depend on the weather and other pathogens and pests.

Given that:

- *P. diplodiella* requires specific conditions for infection;
- infections will be restricted to *V. vinifera* and *Geranium* spp.;

The potential economic consequences are considered to be low and therefore non-negligible.

Environmental consequences

No information on infection of native species by *Pilidiella* spp. was found, but *P. diplodiella* infects geranium species, which are present in New Zealand.

The potential environmental consequences are considered to be low and therefore non-negligible.

Human health consequences

Fungal plant pathogens do not usually infect humans and no examples were found in the literature of *P. diplodiella* infecting humans or causing human health effects from consuming *P. diplodiella* infected fruit.

The potential human health consequences are considered to be negligible.

11.2.2.5 Risk estimation

The likelihood of entry and exposure are low, and the likelihood of establishment is moderate. Establishment of *P. diplodiella* would result in low economic and environmental consequences to New Zealand. *As a result the risk estimate for* P. diplodiella *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

11.2.2.6 Assessment of uncertainty

Whether uninfected fruit will carry spores, or how viable spores are on uninfected fruit is uncertain. If *P. diplodiella* is controlled in the field by application of fungicides after hailstorms and via bagging, the likelihood of entry may be negligible. Whether spores can infect previously uninfected berries when they are discarded is unclear. If they cannot, the risk of exposure may be an overestimate.

How fast infected fruit will develop symptoms, especially under refrigerated transport is unclear. It is assumed that infected and damaged berries are unlikely to be exported, but if this assumption is incorrect then the likelihood of entry may be an underestimate.

11.2.3 Risk management

11.2.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. Due to the weather dependency this could be a viable option. The distribution within China is currently unclear; therefore pest freedom status could be a viable option if pest freedom is proven.

In-field control and surveillance

Control of *P. diplodiella* in China is an option, for example a specified regime of fungicide application (especially after hailstorms) and mandating removal of diseased berries, pedicels and fruit spurs. Studies suggest that certain fungicides (for instance Bordeaux mixture, orthocide, zineb, MCO, fuclasin, liro-maneb, and lirotan) can control the fungus if applied within 18 hours of hailstorms. Dichlofluanid (1000 ppm) has also showed curative action (Bisiach and Viterbo, 1973). Therefore, in regions where *P. diplodiella* is present, a regime of appropriate fungicides to be applied when the risk of *P. diplodiella* infection is high (after hail, or when sun scorch, birds or other pathogens result in wounds) would be a viable management option.

Pre-export phytosanitary visual inspection

Inspections would probably detect infections of *P. diplodiella* or grape bunches that were damaged but will not detect spores, which may cause infection of previously uninfected grapes after they are discarded. Surveys of export orchard areas would be expected to detect *P. diplodiella* presence, and any grape bunches with infected berries should not be permitted to be harvested and exported to New Zealand. Phytosanitary visual inspection is considered an option when combined with bagging.

Bagging

The practice of bagging individual fruit is likely to mitigate the spread and landing of spores on the fruit surface. Bagging can only mitigate the risk if the bags are left on the grapes up until harvest. Bagging is considered an option when combined with phytosanitary visual inspection.

11.3 *Guignardia bidwellii*

Scientific name (telemorph): *Guignardia bidwellii* (Ellis) Viala & Ravaz 1892 (Botryosphaeriales: Botryosphaeriaceae)
Scientific name (anamorph): *Phyllosticta ampelicida* (Engelm.) (1973)
Other relevant scientific names: *Sphaeria bidwellii* Ellis; *Physalospora bidwellii* (Ellis) Sacc.; *Laestadia bidwellii* (Ellis) Viala & Ravaz; *Sphaerella bidwellii* (Ellis) Ellis; *Carlia bidwellii* (Ellis) Magnus; *Phyllachorella bidwellii* (Ellis) Theiss.; *Botryosphaeria bidwellii* (Ellis) Petr.
Common name: Black rot

11.3.1 Hazard identification

11.3.1.1 Taxonomy

Some taxonomic confusion exists; in some cases *Guignardia bidwellii* is stated as the telemorph of *G. uvicola*, but these are separate fungi (Steel *et al*, 2007).

11.3.1.2 New Zealand status

Recorded as absent from New Zealand (Landcare Research, 2009). Not recorded in PPIN (2009).

11.3.1.3 Biology

G. bidwellii is a significant fungal pathogen of grapes. It is commonly known as "black rot" because it causes circular necrotic reddish-to-black spots on leaves, and purple-black lesions on shoots, stalks and tendrils. Berries are infected when young, showing pale-coloured spots with a sunken centre, and finally become shrunken, black and wrinkled (CPC, 2007).

Maximum infection rates occurred from when shoots were 10–20 cm long up to early berry development (Ferrin and Ramsdell, 1977). Ascospores do not germinate at 98 or 100% RH, but do germinate in water. Infection of grape leaves was most rapid at 27ºC and was slowed down at 32ºC and 10ºC (Ferrin and Ramsdell, 1977; Spotts, 1977). Young leaves, shoots, pedicels and young berries are vulnerable to infection by ascospores, but older leaves are not (Kuo and Hoch, 1996; CPC, 2007). Berry infection occurs from mid-bloom until the berries begin to change colour (veraison) (Ferrin and Ramsdell, 1978; CPC, 2007).

Incubation time on grapevine was between 1 week (at 21ºC) and 2 weeks (at 26.5ºC) and was heavily favoured by short periods of rain (Spotts, 1980). The incubation time varies depending among others on grape cultivar and maturity of the grape at infection. Grapes of *V. vinifera* varieties 'Chardonnay' and 'Riesling' exhibited a period of maximum susceptibility for 3 to 5 weeks starting from midbloom. Some berries retained their susceptibility until 6 to 7 weeks postbloom. Newly symptomatic berries continued to appear for over 1 month after inoculation of older fruits. Age-related host resistance was manifested both as a decline in susceptibility and a significant increase in incubation period (Hoffman *et al*, 2002). Even accounting for the variability of the time of susceptibility, the time of infection is such that *G. bidwellii* would cause visually obvious symptoms well before harvesting.

Azoxystrobin at 250 grams of active ingredient per hectare showed excellent preventive and curative properties against *G. bidwellii* (Bugaret *et al*, 1998). Serial applications of myclobutanil were relatively ineffective when applied immediately before bloom, but effective when applied tree times, starting immediately prior to bloom and re-applied 2 and 4 weeks later (Hoffman *et al*, 2004). A common theme in studies of fungicide effectiveness is that the timing of application is critical, due to the variability of susceptibility related to berry maturity.

11.3.1.4 Transmission

G. bidwellii is spread by airborne ascospores, which are discharged during rainfall. Discharge peaks between late May and mid-June in the northern hemisphere. *G. bidwellii* can overwinter on grapevine canes (which can be alive or dead) for at least two years (Becker and Pearson, 1996), which may explain its wide distribution (Maixner and Holz, 2003). Overwintering can occur on tendrils, leaves or mummified grapes. The overwintering stage (pycnosclerotia) gives rise to ascomata and ascospores (CPC, 2007).

11.3.1.5 Hosts

Major hosts of *G. bidwellii* include *V. arizonica* (canyon grape), *V. labrusca* (fox grape), *V. vinifera* (grapevine), and *V. rotundifolia* (muscadine grapes). *G. bidwellii* has also been recorded on *Ampelopsis* sp., *Cissus* sp., *Citrus* sp., *Parthenocissus* sp., and *Asplenium nidus* (bird's nest fern) (CPC, 2007).

11.3.1.6 Geographic distribution

G. bidwellii is present in most grapevine-growing regions of the world and on all continents. Specifically, *G. bidwellii* is present in Africa, Asia (among others India, Japan, Korea), Europe, America (among others Canada, USA, Mexico, El Salvador, Argentina, Brazil, Chile) (UK, 1976; Boubals, 1994; Xu *et al*, 1998; CPC, 2007). *G. bidwellii* is present in China (Xu *et al*, 1998).

11.3.1.7 Hazard identification conclusion

Guignardia bidwellii has been recorded on grapevine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *G. bidwellii* is considered to be a potential hazard.

11.3.2 Risk assessment

11.3.2.1 Entry assessment

G. bidwellii could be transmitted via ascospores or as mycelia in infected pedicels or berries. Ascospores are discharged during rainfall, with discharges peaking between late May and mid-June (northern hemisphere). Some ascospores could be present on the surface of grapes, but would not necessarily infect the grape, as *G. bidwellii* does not infect mature grapes. Infected pedicels or immature berries could also carry the pathogen.

Standard practices in Chinese viticulture include a number of applications of fungicides, postharvest cleaning, and a number of postharvest inspections. The effect of the fungicides in reducing the prevalence of *G. bidwellii* is not known, but is likely to be non-negligible. The time of infection is such that *G. bidwellii* would cause visually obvious symptoms well before harvesting. The infected grapes are likely to be detected and discarded during the harvest and packing processes.

Given that:

- *G. bidwelliii* does not infect mature grapes, but ascospores could be present on these grapes;
- immature grapes or pedicels could carry the pathogen;
- due to the timing of infection, infected grapes are likely to be detected;
- viticulture practice in China includes a number of applications of fungicides;

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

11.3.2.2 Exposure assessment

G. bidwellii is spread by airborne ascospores, mainly discharged during rainfall. Some ascospores may be present on the surface of mature table grapes. However, as *G. bidwellii* does not infect mature grapes, no fungal infection, growth and reproduction would occur. It is assumed that there would be insufficient disease pressure on uninfected grapes for a reasonable chance of transmission. The time of maximum ascospore generation is also well before harvesting.

Infected pedicels or immature berries carry the pathogen. Infected table grapes could be discarded in rubbish bins or compost and could act as a source of disease inoculum. *G. bidwellii* could then infect and form spores that can be transmitted by rain splashes causing emission of air-borne ascospores. Moreover, birds could spread infected berries to different locations.

The most significant potential host species in New Zealand are *V. vinifera* and citrus sp. These are widely distributed and often grown in home gardens that are likely to be close to compost heaps or domestic rubbish bins.

Given that:

- ascospores on mature grapes would not have enough disease pressure;
- infected berries or pedicels can be discarded in compost;
- *G. bidwelli* is spread by airborne ascospores, mainly during rainfall;
- host species could be close to place where infected grapes are discarded;

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

11.3.2.3 Establishment assessment

The current geographical distribution of *G. bidwellii* includes most grapevine-growing regions of the world and all continents, including countries with a similar climate to New Zealand (for example France). Infection of grapevine is most rapid at 27ºC but occurs as low as 10ºC, and incubation time on grapevine is faster at 21ºC than at 26.5ºC. Spread of *G. bidwellii* requires rain splashes to liberate ascospores, which are airborne. No obvious climate or temperature barriers to *G. bidwellii* establishment in New Zealand exist.

Given that:

- the current geographical distribution of *G. bidwellii* includes most grapevine-growing regions of the world;
- infection occurs as temperatures as low as 10ºC but most rapid at 27ºC;
- no obvious climate barriers for establishment in New Zealand exist;

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

11.3.2.4 Consequence assessment

Economic consequences

G. bidwellii is a significant pathogen of *V. vinifera* but is not thought to be a major pathogen of genera other than *Vitis* spp., so economic consequences are likely to be restricted to *V. vinifera*. Control measures are available, but would incur further economic cost. *G. bidwellii* causes significant crop losses of up to 100% at an early stage and would be very difficult to eradicate as it can overwinter on grapevine canes, tendrils, leaves or mummified grapes. Once established, eradication is likely to be impossible and New Zealand's status of freedom from *G. bidwellii* would be lost. Economic consequences would depend on the final distribution of the pathogen, the host preferences, level of damage to hosts, and the cost of control measures. There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- *G. bidwellii* can cause crop losses of up to 100%;
- eradication is likely to be impossible;
- control measures would impose a cost, as would loss of status of freedom;

The potential economic consequences are considered to be moderate and therefore non-negligible.

Environmental consequences

Damage to New Zealand's environment through infection of native species by *G. bidwellii* is difficult to estimate, but cannot be excluded.

The potential environmental consequences are considered to be low and therefore non-negligible.

Human health consequences

Guignardia spp. do not infect humans and no human health effects from consuming *Guignardia* spp.-infected fruit are known.

The potential human health consequences are considered to be negligible.

11.3.2.5 Risk estimation

The likelihood of entry is low, of exposure is moderate, and the likelihood of establishment is high. Establishment of *G. bidwellii* would result in moderate economic and low environmental consequences to New Zealand. *As a result the risk estimate for* G. bidwellii *is non-negligible and it is classified as a hazard on the commodity. Therefore risk management measures can be justified.*

11.3.2.6 Assessment of uncertainty

The ability of uninfected fruit to carry spores and the viability of spores on uninfected fruit are uncertain. This viability may also depend on the transit time of the fruit. The assessment that ascospores on uninfected grapes are not a viable means of transmission depends on the assumption that mature grapes cannot be infected, even when wounded, discarded or attacked by other pathogens. How fast infected fruit will develop symptoms under refrigerated transport is unclear.

11.3.3 Risk management

11.3.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. *G. bidwellii* has not been reported from all provinces and therefore this could be a viable option.

In-field control and surveillance

Control of G. bidwelli would require surveillance and/or inspection of table grapes to confirm that *G. bidwelli* is not present. Therefore, in regions where *G. uvicola* is present, a new regime of appropriate fungicides and/or mandated removal of leaves, diseased berries, pedicels and fruit spurs is considered a viable management option.

Pre-export phytosanitary visual inspection

Infections of *G. bidwellii* are likely to cause visually obvious symptoms. Surveys of export orchard areas would be expected to detect *G. bidwellii* presence, and any grape bunches with infected berries should not be permitted to be harvested and exported to New Zealand. The journey time to New Zealand would allow extra time for symptoms to develop. Phytosanitary visual inspection is considered a viable option when combined with bagging.

Bagging

The practice of bagging individual fruit is likely to mitigate the spread and landing of spores on the fruit surface. Bagging can only mitigate the risk if the bags are left on the grapes up until harvest. Bagging is considered an option when combined with phytosanitary visual inspection.

11.4 *Monilinia fructigena*

Scientific name (teleomorph): *Monilinia fructigena* Honey 1945 (Helotiales: Sclerotiniaceae)
Scientific name (anamorph): *Monilia fructigena* (Pers.) Pers. 1801
Other relevant scientific names: *Sclerotinia fructigena* Aderh. & Ruhlan, nom. illegit
Common name: Brown rot

11.4.1 Hazard identification

11.4.1.1 New Zealand status

Monilinia fructigena is recorded as absent from New Zealand (Landcare Research, 2009) Not recorded in PPIN (2009).

11.4.1.2 Biology

M. fructigena is a fungal pathogen that attacks a wide variety of crops especially of rosaceous fruits (*Malus* spp., *Pyrus* spp., *Prunus* spp.) but also attacks grapevine, which is considered a minor host (CPC, 2007). The pathogen usually infects the fruit, causing brown fruit rot, but can also cause twig blight and canker. Initial infection is via wounds caused by mechanical damage via insects, bird attack, or other pathogens (Rekhviashvili, 1975). Birds are the most important wounding agents on pear in the UK, accounting for about 70% of damaged that resulted in infection (Xu *et al*, 2001). The pathogen can spread via contact between fruits, but this was shown to be considerably less important, especially in pears (Xu *et al*, 2001). Infected fruit is initially penetrated at wound sites, and mycelial growth follows. Tissues in the centre of the fruit rot away, leaving a hollow sclerotial sphere of leathery/rubbery consistency. Twigs or peduncles can become infected (CPC, 2007) showing cankers.

The spores are not actively discharged but are set free by air current and wind. The conidiophores elevate the spore chains for better exposure. Moreover, infected fruit and peduncles are well placed for efficient take-off and dispersal of spores, except when mummified fruit has fallen on the ground. Arial dispersal spreads spores over a wider area, whilst water splash spreads spores only short-range (CPC, 2007).

Most of the disease observed on pear was primary infection via spores, all associated with damage. Contact spread between pear fruit accounted for between 11 and 15% of total observed rot. Aggregation of diseased fruits among trees is significant. The spatial characteristics of *M. fructigena* are more determined by the activities of the wounding agents than by the dispersal characteristics of the conidia. Dispersal indicated that rain splash-dispersal is more important than airborne conidia in initiating infections (Xu *et al*, 2001).

Wounding is essential for the infection by *M. fructigena*, non-wounded fruit does not get infected. Wounds on younger fruit are more resistant to infection than wounds on older fruit. In general, younger fruit are more resistant to infection. Moreover, the older the wound, the more resistant it is to infection. The incubation period on detached fruit is generally very short (Xu and Robinson, 2000). Late-infected fruits have significantly higher sporulation intensity per sporulating fruit compared with earlier infected fruit, which becomes partly mummified. The number of infected fruits resulting in sporulation is higher at 9–10°C than at higher temperatures (van Leeuwen *et al*, 2002). Healthy looking fruit can be contaminated with spores at harvest and can decay during storage. Generally, further differentiation and growth of the pathogen takes place after ripening. Maximum growth and expression of symptoms occurs between 23–27°C, and is significantly retarded above 32°C. Little development occurs at low temperatures (Roberts and Dunegan, 1932).

11.4.1.3 Transmission

Mummified fruits can overwinter either on trees or on the ground beneath and at the start of the growing season give rise to sporodochia and, infrequently, apothecia. In addition, conidia can form on other infected tissues such as cankers and blighted twigs. Spores are spread by air currents and water splashes. Spread by mycelial growth (CPC, 2007) is limited. Birds and almost all insects have the potential to spread *M. fructigena* by picking up and carrying spores. In particular, birds, *Vespula* wasps and nitidulid beetles are thought to be vectors (Byrde and Willetts, 1977).

11.4.1.4 Hosts

Hosts of *M. fructigena* include many commercial pome fruit crops, other rosaceous fruit crops, and some berry and nut crops. Hosts include among others *Malus domestica* (apple), *Prunus* spp.(stone fruit), *Pyrus* spp.(pears), *Capsicum* spp.(peppers), *Diospyros kaki* (persimmon), *Ficus carica* (fig), *Fragaria* × *ananassa* (strawberry), *Solanum lycopersicum* (tomato), *Rosa* spp.(roses), *Rubus* spp. (blackberry, raspberry), *Vaccinium* sp.(blueberries) and *V. vinifera* (grapevine) (CPC, 2007).

11.4.1.5 Geographic distribution

M. fructigena is extremely widespread in Europe and is also present in America (Brazil, Chile, Uruguay), Africa (Egypt, Morocco), and Asia (among others India, Japan, Korea) (CPC, 2007).

Within China, *M. fructigena* is present in Anhui, Henan, Hubei, Hunan, Jiangsu, Liaoning, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan, and Zhejiang (CPC, 2007, Fan *et al*, 2007; AQSIS, 2007b).

11.4.1.6 Hazard identification conclusion

Monilinia fructigena has been recorded on grapevine, and is associated with grapes. It is present in China and is not known to be present in New Zealand. Therefore, *M. fructigena* is considered to be a potential hazard.

11.4.2 Risk assessment

11.4.2.1 Entry assessment

M. fructigena could enter New Zealand on symptomatic fruit or woody tissue (as mycelia) or as spores on asymptomatic table grapes. Symptomatic fruit is likely to be identified at the packing stage and would not be exported. However, some fruit may develop symptoms after packing and development of symptoms may be delayed by low temperatures. Some fruit may carry spores but be completely asymptomatic or uninfected. These all provide viable means of entry. There is significant aggregation of diseased fruits among trees.

Given that:

- *Vitis vinifera* is a minor host;
- some grapes may develop symptoms after packing and cold may delay symptoms;
- grapes need to be damaged for infection;
- some grapes may carry spores but remain asymptomatic;

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

11.4.2.2 Exposure assessment

M. fructigena can be spread by insects, birds, wind and rain splashes. The spores are not actively discharged but are set free by air current and wind. The conidiophores elevate the spore chains for better exposure. Also, infected fruit and peduncles on trees are well placed for efficient take-off and dispersal of spores, except when mummified fruit has fallen on the ground. Table grapes that develop symptoms after entry into New Zealand could be discarded in household rubbish or compost heaps, and could continue to develop after being discarded, providing a new source of spores for spread by wind, rain, or vectors. Additionally, asymptomatic table grapes or uninfected table grapes carrying spores could be discarded, and (if wounded in the process) could develop symptoms, again providing a source of spores.

The range of potential host species in New Zealand is extremely wide and includes apple, stonefruit, pear, pepper, strawberry, tomato, rose, and grapevine, many of which are grown in home gardens that are likely to be close to compost heaps or domestic rubbish bins.

Given that:

- asymptomatic table grapes could be discarded and develop symptoms;
- *M. fructigena* can easily be spread by insects, birds, wind and rain splashes, but the discharge of spores is not actively;
- an extremely wide range of potential hosts is present in New Zealand;

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

11.4.2.3 Establishment assessment

The current geographical distribution of *M. fructigena* includes countries with a similar climate to New Zealand, for example the UK, and also includes countries with typically colder winters, for example Norway, or hotter summers, for instance Spain. Additionally, two closely related fungi (*M. fructicola* and *M. laxa*) are already present and established in New Zealand. It is reasonable to assume that *M. fructigena* would be able to establish in the New Zealand climate.

Given that:

- the current distribution of *M. fructigena* includes countries with similar climate, warmer climate and colder climate;
- two closely related fungi are already present in New Zealand;

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

11.4.2.4 Consequence assessment

Economic consequences

Although *M. fructigena* causes significant damage both before and after harvest, the overall losses it causes are not easy to assess. 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), although it occasionally causes economically important losses of apple and plum fruit in Europe, particularly in hot and humid summers (CPC, 2007). There may also be adverse effects on market access if industry has to change from current low chemical production regimes to high chemical usage, leaving extra residue.

Given that:

- *M fructigena* causes damage before and after harvest;
- *M fructigena* can cause economically important losses in apple and plum fruit;
- *M fructigena* has a wide host range;

The potential economic consequences are considered to be moderate and therefore non-negligible.

Environmental consequences

M. fructicola or *M. laxa* have not been recorded infecting any New Zealand native species but this may be because no specific surveys have been carried out. 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 consequences are considered to be low and therefore non-negligible.

Human health consequences

Monilinia spp. do not infect humans and there are no known human health effects from consuming fruit infected by *Monilinia* sp.

The potential human health consequences are considered to be negligible.

11.4.2.5 Risk estimation

The likelihood of entry is low, and the likelihood of exposure is moderate and the likelihood of establishment is high. Establishment of *M. fructigena* in New Zealand would result in moderate economic consequences and low environmental consequences. *As a result the risk estimate for* M. fructigena *is non-negligible and it is classified as a hazard on the commodity. Therefore risk management measures can be justified.*

11.4.2.6 Assessment of uncertainty

The likelihood that uninfected fruit will carry spores, and the viability of spores on uninfected fruit are uncertain. The viability of spores may also depend on the transit time of the fruit and the in-transit temperatures. How rapidly infected fruit develops symptoms is unclear, especially under refrigerated transport. Whether *M. fructigena* can effectively establish by the passive discharge of spores from fruit left in the lower part of trees is uncertain.

11.4.3 Risk management

11.4.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. *M. fructigena* is not present in all provinces of China and therefore this pest freedom status could be a viable option.

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. 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.

Pre-export phytosanitary visual inspection

Primary infection by *M. fructigena* is through wounds and wounded fruit and would 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 phytosanitary 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 Lancu, 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).

Bagging of fruit

The practice of bagging individual fruit is likely to mitigate the spread and landing of spores on the fruit surface. Bagging can only mitigate the risk if the bags are left on the grapes up until harvest. Bagging is considered an option when combined with phytosanitary visual inspection.

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12 Risk assessment of potential hazards – Hitchhikers

12.1 Araneae – spiders

Scientific name: *Latrodectus mactans* (Fabricius) (Araneae: Theridiidae)
Other relevant scientific names: *Latrodectus agoyangyang*; *Latrodectus albomaculatus*
Common names: Black widow, Southern black widow, Hourglass spider, Shoe button spider

12.1.1 Hazard identification

There were 10 border interceptions and 47 post-border detections of spiders, spiderlings or eggs from table grapes exported to New Zealand during the period 2000–2001 (MAFBNZ, 2009). These interceptions and a subsequent pest risk assessment identified spiders as a problem hitchhiker species on grapes (Reed and Newland, 2002). *Latrodectus* species were intercepted or detected 12 times during the 2000–2001 season with *Latrodectus mactans* being intercepted four times (Reed and Newland, 2002). The genus *Latrodectus* contains approximately 31 recognised species of venomous spiders (Platnick, 2006). There are around 3100 spider species in 60 families in China (Li, 2008). *L. mactans* is present in China (Li, 2008). Whilst it is likely that a number of spiders may be associated with table grapes, the species involved will not be known until trade commences. *L. mactans* has been selected for assessment as the most likely spider to be associated with table grapes.

12.1.1.1 Taxonomy

The species was reviewed by Levi (1959) as one species with geographic races occurring throughout most of the USA, Europe, southern portions of Africa, and in Asia. Many of these records have subsequently been described as different species and subspecies, but no subsequent revision of the genus has been done. Many of the so-called geographic races of *L. mactans* are in fact valid species. Therefore *L. mactans* is considered a species complex, and some confusion is evident from the literature (Martindale and Newlands, 1982).

12.1.1.2 New Zealand status

L. mactans is not known to be present in New Zealand. Not recorded in: Forster and Forster (1999), PPIN (2009) (accessed 26/03/2009).

12.1.1.3 Biology

This spider received the name “widow” because the female sometimes kills and eats its mate after mating (McCorkle, 2002). Widow spiders are present on every continent except for Antarctica. *Latrodectus mactans* is considered the most venomous spider in North America.

L. mactans builds strong-walled retreats close to the ground, in dark sheltered spaces. However, it also spreads its snares over plants and between grape arbours. This spider is usually not found indoors, although it can seek shelter from cold and rain in for instance garages or storage sheds (McCorkle, 2002).

L. mactans is the largest spider of the family Theridiidae (McCorkle, 2002). The female averages 8–13 mm in body length and with legs extended 25–35 mm. The male is about half the size of the female, 4–6 mm in body length and 12–18 mm with legs extended (Bugguide, 2005). The female has a distinctive red hourglass mark on the underside of her abdomen, covering about one-third of the entire ventral space (Newton Miller, 1935). The hourglass marking consists of two connected red triangles; if the hour glass marking is not connected it is most likely the cousin *L. variolus* (Bugguide, 2005). The male has four pairs of red and white stripes on the side of its abdomen (McCorkle, 2002) and each joint of the legs is orange brown (Bugguide, 2005). The young spiderlings are orange, brown and white (McCorkle, 2002). Juveniles of both sexes resemble the male (Bugguide, 2005). The fourth pair of legs has a distinct comb, a row of strong and curved setae. The comb is used for flinging silk, in an almost liquid state, over entangled prey (D'Amour *et al*, 1936).

L. mactans reproduce sexually, with mating taking place in spring or summer. A female can produce 10–12 egg sacs in one summer, each containing up to 650 eggs (Newton Miller, 1935). An egg sac is about 1.3 cm in diameter. Usually eggs incubate for about 20–30 days. It takes 2 to 4 months for the spiders to mature (Bugguide, 2005). Eggs laid in late autumn hatch the following spring (Newton Miller, 1935). Once the female produces her egg sacs she guards them until the spiderlings hatch. More than one egg sac can be present in a nest (D'Amour *et al*, 1936). After they have hatched they leave the web (McCorkle, 2002). The eggs are laid onto a small web and are covered with silk until they are completely surrounded by an egg sac. The female can also store a lifetime supply or sperm to fertilise all the eggs she will produce (Bugguide, 2005; McCorkle, 2002).

The spiderlings hatch and moult once while inside the egg sac. Then they disperse via ballooning, extruding silk threads and being transported by air currents. When the spiderlings are young they are negatively geotropic, tending to climb upwards. At all stages the spiders are negatively heliotropic, tending to move away from light (D'Amour *et al*, 1936).

The female rarely leaves her web (McCorkle, 2002). Most widow spiders live for two years, although some are known to have lived three years and longer in the wild. During the summer months the females have a strong odour (Newton Miller, 1935).

L. mactans is timid, solitary, cannibalistic and nocturnal. The female never remains upright on her legs, but hangs upside down making the red hourglass marking visible as a warning sign (Newton Miller, 1935). When disturbed the spider will drop out of its web and pretend it is dead (McCorkle, 2002). The web is typically a three-dimensional, unorganised mass of silk, easiest described as an inverted goblet. The threads of the web are strong: water from a waterhose upon full force will not destroy the web (Newton Miller, 1935). If the web is in use, the female will be in or very near to the web (Bugguide, 2005). The web can be as big as 1.5 meters. *L. mactans* can hear sounds, but the greatest sensitivity is towards vibrations, especially via its web. With their eight eyes they can only see to about 25 cm (Newton Miller, 1935). *L. mactans* is exclusively carnivorous but can go without food for three months (Newton Miller, 1935).

The bite of this spider is voluntary and therefore does not necessarily contain venom. The venom acts upon the central nervous system (D'Amour *et al*, 1936). The spiders are found up to altitudes of 2500 metres. The spider population can be very high. There have been reports of grapes going to waste because pickers have refused to work among the spider infested vines (D'Amour *et al*, 1936).

12.1.1.4 Prey affected

This spider is purely carnivorous. It feeds on flies, beetles, grasshoppers, ants and other species that get stuck in its web (Nyffeler *et al*, 1988). It has been observed to eat a small mouse or Western cicadas, which are nearly as big as a mouse (D'Amour *et al*, 1936; Nyffeler *et al*, 1988).

12.1.1.5 Geographic distribution

L. mactans is widespread throughout the world between latitudes 55°N and 50°S (Newlands, 1975). It has been reported from USA, Canada, West-Indies (D'Amour *et al*, 1936), Mexico (Jiminez and Aguilar, 1994), Africa (Newlands, 1975), Japan (Tanikawa, 2009), China (Li, 2008; Animalnet, 2008; Ushkaryov *et al*, 2004).

12.1.1.6 Hazard identification conclusion

Latrodectus mactans has been recorded on grapevines associated with fruit although it does not feed on the berries. On many occasions it has been intercepted on table grapes imported into New Zealand. It is present in China and is not known to be present in New Zealand. Therefore, *L. mactans* is considered to be a potential hazard.

12.1.2 Risk assessment

12.1.2.1 Entry assessment

L. mactans does not directly feed on the grapes, rather it uses bunches of grapes as habitat. The likelihood of entry is dependent on its abundance both in vineyards and in the packing facility, on the volume of grapes being transported, on the detection rate of standard grading and packing process and on the survival during transport (Reed and Newland, 2002). The abundance of *L. mactans* in grapevines in China is not known, however, 112 Araneae have been intercepted on goods coming to New Zealand from China (MAFBNZ, 2009). Moreover, spiders have been intercepted on table grapes exported from other countries. *L. mactans* can go without food for three months (Newton Miller, 1935), so it would survive the trip from China to New Zealand. Although from the relatively large size of *L. mactans* and the webbing covering the eggsacs easy detection during the harvesting and packing processes would be expected, the interception records indicate that this is not always the case.

Given that:

- *L. mactans* uses grape bunches as habitat;
- *L. mactans* is present in China but its abundance in grapevines is unknown;
- the spider or signs such as webbing are likely to be detected during harvest and packing processes;
- interception records show that *L. mactans* can reach New Zealand in grapes;

- *L. mactans* can go without food for three months;

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

12.1.2.2 Exposure assessment

If spiders, eggs or hatchlings are not detected on the grape bunches, they can move from these bunches (after eggs are hatched) on arrival of the grapes in New Zealand and go in search for a suitable habitat. The spiders normally build webs close to the ground, sometimes in places like garages, storage sheds, under houses, or in holes in the ground. Easy access to a suitable habitat is available almost everywhere, especially if grapes are not kept in a refrigerator. The spiderlings disperse long distances via ballooning in air currents, which greatly enhances spread. If people found these spiders in New Zealand, they would most likely kill them or move them outdoors depending on the person's attitude towards spiders. Killing them would reduce the exposure, moving them outdoors would greatly enhance the likelihood of exposure to a suitable habitat.

Given that:

- spiders are very mobile and would move readily to suitable habitat;
- easy access to a suitable habitat is available in almost every situation;

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

12.1.2.3 Establishment assessment

Black widow spiders reproduce sexually but the female can store a lifetime supply of sperm to fertilise all the eggs she will produce. So in theory a single mated female or one carrying eggs would be capable of founding a population. Egg sacs can contain up to 650 eggs. *L. mactans* can survive cold winter months, but needs warmer and drier climates to reproduce. This would make the East Coast of the North Island, Canterbury, Otago and possibly Nelson, Marlborough and the Wairarapa as likely places for establishment (Reed and Newland, 2002).

Given that:

- a single mated female would be capable of founding a population;
- the warmer and drier parts of New Zealand (especially eastern parts) would have very suitable climates for *L. mactans* to establish;

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

12.1.2.4 Consequence assessment

Economic consequences

L. mactans consumes large numbers of insects, including an array of pests (McCorkle, 2002). This may be beneficial. Conversely, there have been reports of grapes going to waste because pickers have refused to work among the spider infested vines. The harvest of certain crops can become more dangerous and therefore more expensive. Moreover, establishment could affect current biological control programmes by reducing the number of beneficial predators.

Given that:

- *L. mactans* eats a variety of insects, both pests and beneficials;
- harvest of crops may become more expensive if workers are reluctant to work amongst those that might harbour *L. mactans*;

The potential economic consequences are considered to be low and therefore non-negligible.

Environmental consequences

The black widow spider is a strong hunter. In laboratory observations it out-competes any other spider, for example, the much bigger tarantula (Newton Miller, 1935; D'Amour *et al*, 1936). *L. mactans* could out-compete or kill native spiders. Evidence that the native, *L. katipo*, has already been partially displaced by the South African species *Steatoda capensis* (Hann, 1990) suggests that native spiders could be displaced further by *L. mactans*. Moreover, *L. mactans* consumes a large array of insects, not all of which will be pests. Any new *Latrodectus* species could be a threat to some of New Zealand's threatened invertebrates, reptiles and amphibians in cases where their distributional ranges overlap through competition for food or by killing them for food. Native frogs are not larger than a small mouse and could potentially be prey for this spider. However, the frogs are largely restricted in distribution and unlikely to occur in the same habitat.

Given that:

- *L. mactans* could out-compete or kill other spiders including native spiders;
- competition with *L. mactans* could reduce populations of the native *L. katipo*;
- *L. mactans* could be a threat to some threatened invertebrates, reptiles and amphibians indirectly through competition for food or directly by killing them;

The potential environmental consequences are considered to be moderate and therefore non-negligible.

Human health consequences

L. mactans is not aggressive and usually only bites humans when brought abruptly into contact with human skin. The venom is neurotoxic. A bitten human suffers painful rigidity and the bite can result in death within 18 to 36 hours. Mortality is predicted between 4% and 6% in untreated cases. This is based upon reported details and the actual mortality rate is expected to be lower than 5% (Newlands, 1975). The bite is distinguished by a double puncture wound. The venom of *L. mactans* is reported as more toxic than most snake venoms and has an LD_{50} of 0.9 mg/kg in mouse (Nellis, 1997) and it is considered the most venomous spider in North America (Bugguide, 2005; McCorkle, 2002). The injection of venom is controlled by the spider, thus a bite may range from inconsequential to severe. In a recent 10-year period in the USA, about 14% of all deaths due to poisonous and venomous creatures were due to black widow bites (Nellis, 1997). The eggs are also poisonous (D'Amour *et al*, 1936). The adult male and the spiderlings are harmless because they are smaller and incapable of biting through human skin (Bugguide, 2005). Social and cultural impacts could result from the establishment of new venomous species of spiders, especially as New Zealand is relatively free of venomous spiders. Arachnophobia could be enhanced and an increase in the number of reported spider bites and mortalities from venomous spiders are likely if it established.

Given that:

- *L. mactans* can bite humans and inject a neurotoxic venom;
- humans can die from untreated bites from *L. mactans*;

The potential human health consequences of establishment are considered to be high and therefore non-negligible.

12.1.2.5 Risk estimation

The likelihood of entry is considered to be low to moderate and the likelihood of exposure is considered to be high. The likelihood of establishment is considered to be moderate to high, with the potential economic consequences of establishment considered to be extremely low. The potential environmental consequences of establishment are considered to be moderate, and the potential human health consequences of establishment are considered to be high. *As a result the risk estimate for* Latrodectus mactans *is non-negligible and it is classified as a hazard in the commodity. Therefore risk management measures can be justified.*

12.1.2.6 Assessment of uncertainty

Spiders have no biological host relationship with grapes, therefore there is uncertainty over the abundance of spiders on table grapes from China. Moreover, there is uncertainty about which species of spiders are associated with the table grapes. *Latrodectus mactans* is a hitchhiker species with well known impacts. The risk from other species is less certain.

12.1.3 Risk management

12.1.3.1 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

An area can be declared a pest free area or a pest free place of production, in agreement with ISPM 4 or 10 respectively (IPPC, 2007). Pest freedom status is achieved via a systems approach and trapping to monitor population levels in and around orchards. Both ISPM measures rely on systems to establish freedom, phytosanitary measures to maintain freedom and checks to verify freedom has been maintained, resulting in official pest-free certification of the area or place of production. The current spread of *L. mactans* in China is unknown. Pest free area status may be an option for table grapes exported from some provinces. Under appropriate conditions a pest free area or a pest free place of production declaration should be considered an effective phytosanitary measure against *L. mactans*.

Bagging

Individual bagging of fruit is likely to prevent spiders from reaching the surface of the fruit. However, bagging will only be a viable risk mitigation option if the bags are in place during the whole growing season, right up until harvest of the grapes. If bagging occurs until harvest it is considered a viable option when combined with phytosanitary visual inspection.

Pre-export phytosanitary visual inspection

Post-border interceptions in New Zealand indicate that spiders can escape pre-export phytosanitary visual inspection. This may be due to the shape of grape bunches and places to hide deep within the bunch. This is enhanced by the fact these spiders are negatively heliotropic, tending to move away from light. A thorough pre-export phytosanitary visual inspection should be able to detect spiders or eggs, but experience with the import of table grapes from other countries has shown inspection is not completely effective. Therefore, pre-export phytosanitary visual inspection is considered a viable measure when combined with bagging.

SO_2 fumigation

The current procedure for the importation of grapes from California into New Zealand requires treatment by fumigation with a minimum of 1% SO_2 and 6% CO_2 for a minimum of 30 minutes from the time the minimum fumigant concentration is first reached (MAFBNZ, 2008) to mitigate the risks posed by regulated spiders. The commodity has to reach at least 16°C before treatments can begin. This is 92% effective under the best conditions, so on its own it will not be able to mitigate the likelihood of entry to a negligible level (Reed and Newland, 2002). The Australian quarantine department currently requires table grapes from the USA to contain sulphur dual release (G2) pads and all table grapes have to be fumigated with 1% SO_2 and 6% CO_2 for 30 minutes (AQIS, 2000). The effects of fumigation on egg sacs, juveniles or species other than *Latrodectus* spp. are currently unknown. Therefore, sulphur dioxide fumigation will assist in reducing the likelihood of entry, but is not considered to be sufficient as a single measure.

Methyl bromide fumigation

MAFBNZ (2002) cites experimental work done by Shorey and Wood (1991) on black widow spiders (*L. hesperus*). 100 percent mortality was obtained with treatment at 16 g/m^3 for 24 hours at 7.2^oC (concentration time product of 384 $g*h/m^3$). The maximum concentration time products suggested by USDA for treatment of external feeders of grapes (TQAU USDA, 2008) appear not sufficient to ensure 100% mortality of *L. hesperus*. Rates that would ensure 100% mortality for spiders would be damaging to grapes and therefore methyl bromide is not considered a viable option.

12.2 *Arboridia apicalis* – grape leafhopper

Experience of intercepted organisms from imported table grape pathways indicates that table grapes are often associated with hitchhiker species. That is, species that have an opportunistic rather than a biological host relationship with the commodity. Since there is rarely much published literature on the association, interception records are particularly valuable in demonstrating the association. The following species has been included as an example of a possible hitchhiker species on table grapes from China.

Scientific name: *Arboridia apicalis* (Nawa, 1913) (Cicadellidae: Typhlocybinae)
Other relevant scientific names: *Erythroneura apicalis* (Nawa); *Zygina apicalis* Nawa; *Erythroneura sandagouensis* Vilbaste. Also mis-spelt as *Aboridia apicalis*
Common names: grape leafhopper, grape variegated leafhopper (Ma *et al*, 2004)

12.2.1 Hazard identification

12.2.1.1 Taxonomy

Arboridia apicalis (Nawa, 1913) (Cicadellidae: Typhlocybinae) seems to be the current name. Synonyms recorded are: *Erythroneura apicalis* (Nawa); *Zygina apicalis* Nawa; *Erythroneura sandagouensis* Vilbaste (Dmitriev and Dietrich, 2003–2008). *A. apicalis* has been used in recent Risk Analyses from US and Australia (Anonymous, 2002, 1999a, b). *E. apicalis* has been used in recent literature relating to China (for example CCM International Ltd, 2008; Zheng *et al*, 2005) as has *Zygina apicalis* (Ma *et al*, 2004).

12.2.1.2 New Zealand status

Arboridia apicalis is not known to be present in New Zealand. Not recorded in: Dmitriev and Dietrich (2006), PPIN (2009).

12.2.1.3 Biology

Leafhoppers are commonly leaf feeders, feeding on mesophyll, usually on the underside of leaves. They puncture the leaf surface with their piercing-sucking mouthparts and suck out the cell contents. The damaged foliage interferes with photosynthesis and reduces plant vigour. In addition, sooty moulds grow on the exudate from feeding leafhoppers and block light available for photosynthesis. Some leafhoppers can vector plant pathogens.

Miyazaki (1991) studied the biology of *A. apicalis* in several vineyards in Shimane Prefecture, Japan. Four peaks of adult numbers occurred in a year: overwintering adults from end of April to beginning of June, first generation adults from the end of June to the beginning of July, second generation adults from beginning of August to the beginning of September, and the third generation from the middle of September to the end of October. First generation nymphs appeared in vineyards at the beginning of June. The threshold temperatures for eggs, nymphs, preoviposition and the period from egg to oviposition was 8.4, 7.2, 13.0 and 10.5^{o}C respectively. Egg and nymph development was not affected by photoperiod conditions. Seasonal development of ovaries was investigated from May to

December: ovaries of females collected before the end of August developed to maturity; after September, females did not lay eggs and their ovaries were undeveloped. Reproductive diapause was induced by short photoperiod, with the critical day length for induction being under 14 hours. The stages sensitive to the short photoperiod were third- to fifth-instar nymphs, especially the fourth- to fifth-instars. The autumn population started diapause at the beginning of September and terminated diapause at the beginning of November. Females started to lay eggs after 45 days at 20^{o}C. A strong correlation was observed between sucking injury to leaves and cicadellid density on leaves. Damage reached a maximum with a pest density of more than 20 per leaf.

Ma and others (2004) studied threshold and effective temperature of *A. apicalis* (as *Z. apicalis*) nymphs in Xinjiang, China. Overwintering adults were collected from the field in Turpan on 1 May. Laboratory observations indicated that these adults could survive more than 45 days. Each female adult later produced about 50–60 offspring that survived to breed. The developmental period of the nymph was about 12.6 to 21.1 days at a temperature of 22–28^{o}C, of which the optimum temperature was 28^{o}C. The threshold temperature and effective temperature for nymphs were estimated to be 5.2^{o}C and 307.1 degree-day respectively.

Arboridia apicalis as a vector:

A. apicalis has been reported as transmitting the Grapevine stunt virus (GSV) in Japan (Namba *et al*, 1986). They stated that GSV is an important virus in Japanese viticulture and is phloem limited, and described the GSV particles as small, spherical and around 25 nm in diameter. This was the first report of Cicadellidae as vectors of plant viruses known to the authors (Namba *et al*, 1986). This virus is not present in New Zealand (Pearson *et al*, 2006).

12.2.1.4 Hosts

Zheng and others (2005) describe *A. apicalis* (as *E. apicalis*) as polyphagous because it has been recorded on more than one genus of host plant. Recorded hosts include: *Acer* sp. (maple), *Malus* sp. (apple), *Morus* sp. (mulberry), *Prunus* sp. (cherry, peach), *Vitis* sp. (grape), *Pyrus* (pear) (Dmitriev and Dietrich, 2003–2008; Zheng *et al*, 2005). At least six species of the genus *Arboridia* are pests of *Vitis vinifera* in vineyards in the Palaearctic and Oriental Regions, with different species infesting vineyards in different geographic areas (Aguin Pombo, 2001).

12.2.1.5 Plant parts affected

The genus *Arboridia* is in the Tribe Erythroneurini, the members of which are mesophyll feeders. The symptom of damage by Erythroneurini is a loss of chlorophyll. Most species of *Arboridia* feed on leaf-mesophyll tissue of deciduous trees and shrubs (Aguin Pombo, 2001).

In general, leafhopper nymphs and adults cause direct damage to grape leaves during feeding by puncturing cells and reducing the photosynthetic productivity of individual cells. High populations can lead to all damaged leaves drying up, resulting in sunburned leaf clusters, leaf abscission, and eventually severe yield loss (Bostanian *et al*, 2006).

Literature searches have not indicated any association of *A. apicalis* with grape berries (other than flecks of exudate on the surface which can mark the appearance and therefore diminish the value of the commodity). *A. apicalis* is unlikely to be found on the fruit, especially the juvenile stages of the insect.

Adult *Erythroneura elegantula* and *Erythroneura* sp. (*A. apicalis* has previously been assigned to this closely related genus) have been intercepted at the New Zealand border in association with fresh grapes from USA several times (all either dead or of unknown viability). Since adult leaf hoppers are mobile they could occur anywhere on the host plant, not just the part on which they are feeding. However, they would be likely in many cases to leave the fruit when disturbed during harvest and post-harvest handling. *A. apicalis* (which has not been intercepted on fresh grapes) is therefore regarded as a potential hitchhiker on fresh grapes from China.

12.2.1.6 Geographic distribution

Present in China and nearby countries (Far East of Russia, Japan, Korea, South Korea) (Dmetriev & Dietrich 2003–2008). *A. apicalis* (as *E. apicalis*) is listed as one of the major pests of grapes in Xinjiang in 2008 (CCM International Ltd, 2008). *A. apicalis* is present in the USA, but not in California (Anonymous 1999a).

12.2.1.7 Hazard identification conclusion

Arboridia apicalis is present in China and is not known to be present in New Zealand. Grape is a host species. *A. apicalis* is a leaf feeder and although interception records from other table grape pathways indicated that adults of a closely related genus may be associated with exported fruit, this association has not been demonstrated for this species on table grapes in China. *A. apicalis* is therefore not classed as a potential hazard in this analysis. Should evidence of association become available then this conclusion will be reconsidered.

Please note that although this organisms is not assessed as a hazard on this pathway and 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.

Other potential hitchhiker organisms can be identified from available interception data on table grapes coming into New Zealand from other countries. These records are summarised in Appendix 1. Once trade in table grapes from China starts interception records can be obtained and the status of possible hitchhikers can be confirmed. Risk mitigation measures may be required for these organisms.

12.3 Weed seeds

Seeds are routinely intercepted on table grapes imported into New Zealand from other countries (see Section 3.2), despite the requirement that imported grapes are free of regulated weed seeds. Because of the large number of plant species present in China it is not possible to assess the risk of every weed species that could potentially be present on the table grape bunches. The possible presence of seeds on grape bunches depends on many variables, for instance the location and surroundings of the vineyard or packing station, weed management in and around the vineyard and packing station or even the wind direction around the time of harvest.

Experience with intercepted weed seeds on current imported table grape pathways indicates that table grapes are often contaminated with seeds from other plant species. The seeds can easily get stuck in the complex structure of grape bunches. Since there is rarely published literature on the specific association, interception records are particularly valuable in demonstrating the association. Whilst seeds are often mentioned as important contaminants, they are generally not identified to species level. Most seeds intercepted on table grapes are in the families Zygophyllaceae, Poaceae and Asteraceae (MAFBNZ, 2009). Many of these plants produce large numbers of small, wind blown seeds which would be expected to contaminate bunches of grapes in the vineyard. A few interceptions are of species with larger, spiny seeds such as *Tribulus terrestris.* These are more likely to be indicative of contamination during the harvest and packing processes.

New weed species have the potential to cause production losses and threaten New Zealand's natural heritage if they become established. The possible impact of new weeds in New Zealand is not always easily predicted and can vary considerably from that in their native range (Randall, 1999).

In addition to the direct effects of new weed species establishing here, seeds (including those of species that are already present in New Zealand) may be vectors for plant pests and diseases. Many viruses are shown to be seed transmittable. Moreover, a large number of bacterial and fungal diseases may also be seed transmitted. Nematodes and even arthropods can be carried in the seed (Barrett, 1991; Maas, 1987). Due to the large number of pests and diseases associated with seeds, the importation of seed for sowing for many species is subject to stringent entry conditions (MAF Biosecurity Authority, 2004).

Seeds can be dormant for variable periods of time, depending on the species. For instance, seeds in the grass family Poaceae have recorded longevities from one to fifteen years (Shem Tov and Fennimore, 2003). Moreover, there are reports of seeds germinating following exposure of soil buried for several hundred years (Odum, 1974). Other species survive for shorter periods of time. Therefore, the short time needed for transport from China to New Zealand is not likely to be a mitigating factor.

Given that:

- seeds are routinely intercepted on imported table grapes;

- many seeds will be able to survive transport to New Zealand in association with table grapes;
- at least some seeds are of species not present in New Zealand, and any seed could vector diseases;

Seed contaminants are considered potential hazards.

It is not possible to undertake a detailed risk assessment without knowing which species are involved. The analysis of interception records would give an indication to which weed seeds are likely to be associated with the pathway and escape the mitigations measures. Interception data are intended to be used as a review tool, not as a primary risk mitigation measure or a tool to prove efficacy of a suggested measure. During the packing process, grapes are airbrushed, which will have a mitigating effect. The shipment has to be free of weed seeds (as stated in MAFBNZ biosecurity New Zealand standard 152.02: importation and clearance of fresh fruit and vegetables into New Zealand). An official phytosanitary inspection will have to be performed to assure that the commodity is free of any weed seeds. Lots contaminated with regulated weed seeds at levels exceeding the acceptance level stated in the appropriate sampling plan should be held. Contaminated lots should be treated, reshipped or destroyed at the importer’s expense.

References for Chapter 12

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Appendix 1: Organisms intercepted on table grapes

The following is a list of organisms that have been intercepted, identified to species level and recorded from table grapes imported into New Zealand from Australia, Chile, Mexico and USA over the period 2 February 1987 to 21 October 2008 (MAFBNZ (2009) *Analysis and Profiling Group's interception database.* New Zealand Ministry of Agriculture and Forestry. *Retrieved 08/12/2008*).

Scientific name		
Achaearanea tepidariorum	*Eriopis connexa*	*Opifex fuscus*
Achaearanea veruculata	*Erythroneura elegantula*	*Otiorhynchus corruptor*
Adalia bipunctata	*Estigmene acrea*	*Otiorhynchus rugostriatus*
Agrypnus variabilis	*Eupalopsis jamesi*	*Otiorhynchus sulcatus*
Alternaria alternata	*Forficula auricularia*	*Oxydema longula*
Anystis baccarum	*Formica rufa*	*Pachybrachius inornatus*
Aonidiella aurantii	*Frankliniella occidentalis*	*Panonychus ulmi*
Aphis craccivora	*Fusarium anthophilum*	*Parthenolecanium corni*
Aphis fabae	*Fusarium oxysporum*	*Parthenolecanium persicae*
Aphis gossypii	*Gibberella zeae*	*Phalaenoides glycinae*
Apis mellifera	*Gryllus assimilis*	*Phidippus audax*
Argyrotaenia citrana	*Haptoncus luteolus*	*Phidippus johnsoni*
Asynonychus cervinus	*Harrisina americana*	*Phlyctinus callosus*
Badumna insignis	*Harrisina brillians*	*Pieris rapae*
Badumna longinqua	*Harrisina metallica*	*Planococcus citri*
Blastobasis tarda	*Heliothrips haemorrhoidalis*	*Plutella xylostella*
Blattella germanica	*Hemiberlesia lataniae*	*Polistes chinensis*
Brevipalpus californicus	*Hemiberlesia rapax*	*Proteuxoa comma*
Brevipalpus lewisi	*Hemideina thoracica*	*Pseudococcus calceolariae*
Cadra cautella	*Hippodamia convergens*	*Pseudococcus longispinus*
Cantareus aspersus	*Hippodamia covergens*	*Pseudococcus maritimus*
Caraboctonus keyserlingi	*Hippotion celerio*	*Pseudococcus viburni*
Carpophilus davidsoni	*Hypera postica*	*Reesa vespulae*
Carpophilus hemipterus	*Hypera variablis*	*Rhytidoponera metallica*
Carpophilus ligneus	*Hypoblemum albovittatum*	*Saissetia oleae*
Carpophilus obsoletus	*Ipomoea purpurea*	*Sanogasta maculatipes*
Carystoterpa fingens	*Irenimus aequalis*	*Sitona discoideus*
Cheiracanthium inclusum	*Isopedella cerussata*	*Sitona humeralis*
Cheiracanthium stratioticum	*Ixeuticus martius*	*Sphragisticus nebulosus*
Chondrilla juncea	*Laius bellulus*	*Sylvicola notatus*
Cladosporium cladosporioides	*Lampona cylindrata*	*Taraxacum officinale*
Coccinella repanda	*Latrodectus geometricus*	*Tarsonemus bakeri*
Coleophora inaequalis	*Latrodectus hasselti*	*Tarsonemus waitei*
Colomerus vitis	*Latrodectus hesperus*	*Technomyrmex albipes*
Corticaria serrata	*Latrodectus mactans*	*Tenothrips frici*
Corythucha ciliata	*Leptoglossus gonagra*	*Tetranychus urticae*
Cotinus nitada	*Linepithema humile*	*Thrips tabaci*
Cryptoblabes gnidiella	*Listroderes difficilis*	*Trachelas pacificus*
Cryptophagus cellaris	*Melanophthalma gibbosa*	*Tribulus terrestris*
Dacne fungorum	*Metaphidippus vitis*	*Trichoplusia ni*
Diaspidiotus perniciosus	*Micromus tasmaniae*	*Trigonospila brevifacies*

Scientific name		
Dictyotus caenosus	*Monomorium destructor*	*Urophorus humeralis*
Drepanothrips reuteri	*Naupactus leucoloma*	*Uta stansburiana*
Drosophila melanogaster	*Notoncus ectatommoides*	*Zelus exsanguis*
Dysdera crocata	*Nysius clevelandensis*	
Ephestia figulilella	*Ochetellus glaber*	
Epiphyas postvittana	*Onthophagus tweedensis*	

Appendix 2: Organisms recorded on table grapes

Based on grapevine association records held in online databases (namely CPC 2007; EPPO, 2007; ICTVdb, 2004; PPIN; Bugguide, 2005; Plant Health Australia, 2006; Knowledge Management; MAFBNZ, 2008); and from information kindly provided by the AQSIQ in China (AQSIQ, 2007), the following organisms have been recorded as potentially being associated with table grapes. The organisms identified as potential hazards will be further assessed to determine if they are hazards and if any biosecurity (phytosanitary) measures may be necessary. The table headings are described in more detail in the MAF BNZ risk analysis procedures (2006) which are available online at Http://www.maf.govt.nz .

Scientific name and Authority	Common name	Commodity association (see note 1)	Present in China (reference) (see note 2)	Present in NZ (reference) (see note 3)	Vect-or	In NZ but associat-ion with goods increases hazard	In NZ but geogra-phically bounded	In NZ but has different host associations or strains	No or little informat-ion on organism	Under official control or notifiable	Potent-ial hazard
Bacteria											
Rhizobium radiobacter (syn. *Agrobacterium tumefaciens*) (Beijerinck & van Delden, 1902) Young *et al*, 2001)	Kansas lettuce disease:	N (CPC, 2007)	Y (Bradbury, 1986; Wang *et al*, 2000; Papademetriou and Dent, 2001)	Y (Young, 2000; PPIN, 2009)	N						No?
Xylella fastidiosa	Pierce's Disease	N (CPC, 2007)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009)	N						No
Fungi											
Alternaria alternata	alternaria leaf spot	Y (Swart and Holz, 1991)	Y (Guo *et al*, 2008; Zhao *et al*, 2008; CPC, 2007)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No
Alternaria viticola Brunaud, 1898	brown spot	Y (Ma JunYi *et al*, 2004)	Y (Liu *et al*, 1996)	N (Landcare Research, 2008; PPIN, 2009)	N						Yes

Scientific name and Authority	Common name	Commodity association (see note 1)	Present in China (reference) (see note 2)	Present in NZ (reference) (see note 3)	Vect-or	In NZ but associat-ion with goods increases hazard	In NZ but geogra-phically bounded	In NZ but has different host associations or strains	No or little informat-ion on organism	Under official control or notifiable	Potent-ial hazard
Armillariella tabescens Sing	Dieback, root rot.	N (Chang *et al*, 1983; Zhang and Liu, 2006)	Y (Zhang and Liu, 2006)	N (Landcare Research, 2008; PPIN, 2009)	N						No
Botryotinia fuckeliana (de Bary) Whetzel (1945) (syn. *Botrytis cinerea*)	Gray mold	Y (AQSIQ, 2007; Xie *et al*, 2003)	Y (AQSIQ, 2007; Xie *et al*, 2003; Wei, 2005; Papademetriou and Dent, 2001)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No
Cladosporium cladosporioides	brown leaf spot	Y (Briceno and Latorre, 2007)	Y (Liang and Zeng, 1980)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No
Colletotrichum acutatum Simmonds ex Simmonds	leaf curl	Y (WhitelawWeckert *et al*, 2007)	Y (Zhang *et al*, 2008b)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No
Coniella diplodiella (Speg.) Petr. & Syd., 1927	grapevine white rot	Y (Bisiach and Viterbo, 1973)	Y (Chen *et al*, 1979)	N (Landcare Research, 2008; PPIN, 2009)	N						Yes
Corticum rolfsii West (Teleomorph: *Athelia rolfsii*) (syn. *Pellicularia rolfsii)*	Foot rot	Y (fruit; CPC, 2007)	Y (AQSIQ, 2007; Farr *et al*, 2008)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No
Cryptosporella viticola Red (Anamorph: *Phomopsis viticola*)	Dead arm	Y (CPC, 2007)	Y (AQSIQ, 2007; Farr *et al*, 2008; Papademetriou and Dent, 2001)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No
Elsinoe ampelina (Anamorph: *Sphaceloma ampelinum*, de Bary)	Anthracnose	Y (CPC, 2007; Liu and Wang, 2003)	Y (Farr *et al*, 2008; Liu and Wang, 2003; Papademetriou and Dent, 2001)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No

Scientific name and Authority	Common name	Commodity association (see note 1)	Present in China (reference) (see note 2)	Present in NZ (reference) (see note 3)	Vect-or	In NZ but associat-ion with goods increases hazard	In NZ but geogra-phically bounded	In NZ but has different host associations or strains	No or little informat-ion on organism	Under official control or notifiable	Potent-ial hazard
Fusarium anthophilum	root and stem rot	Y (fruit; Muniz *et al*, 2003)	Y (Farr *et al*, 2008)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No
Fusarium oxysporum	basal rot	N (Omer *et al*, 1999; Ziedan and ElMohamedy, 2008)	Y (Farr *et al*, 2008; Chen *et al*, 2008)	Y (Landcare Research, 2008; PPIN, 2009)	N						No
Fusarium solani (Mart) Sacc	tuber rot	N (CPC, 2007; AQSIQ, 2007)	Y (AQSIQ, 2007; Ji *et al*, 2007; Li *et al*, 2007)	Y (CPC 2007; PPIN, 2009)	N						No
Gibberella zeae	headblight	N (CPC, 2007)	Y (Chen *et al*, 2008; Zhao *et al*, 2005; CPC, 2007)	Y (Landcare Research, 2008; CPC, 2007; PPIN, 2009)	N						No
Glomerella cingulata (Ston.) Spauld et Schrenk	anthracnose	Y (Sonego *et al*, 2005)	Y (Ren *et al*, 2008b; Xiao *et al*, 2008; Papademetriou and Dent, 2001)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No~	No	No	No
Greeneria uvicola	bitter rot of grapevine	Y (Critopoulos and D., 1961)	N (CPC, 2007)	N (Landcare Research, 2008; PPIN, 2009)	N						No
Guignardia bidwellii (Ell.) Viala et Rav.	Black rot	Y (Kuo and Hoch, 1996)	Y (Xu Ling *et al*, 1998)	N (Landcare Research, 2008; PPIN, 2009)	N						Yes

Scientific name and Authority	Common name	Commodity association (see note 1)	Present in China (reference) (see note 2)	Present in NZ (reference) (see note 3)	Vect-or	In NZ but associat-ion with goods increases hazard	In NZ but geogra-phically bounded	In NZ but has different host associations or strains	No or little informat-ion on organism	Under official control or notifiable	Potent-ial hazard
Helicobasidium mompa Tanaka	Violet root rot	N (Kawai *et al*, 1986; Sugimoto, 2002; AQSIQ, 2007)	Y (AQSIQ, 2007; Farr *et al*, 2008)	N (Landcare Research, 2008; PPIN, 2009)	N						No
Inonotus hispidus (Bull.) P. Karst.	shaggy bracket	N (Pegler *et al*, 1968)	Y (Farr *et al*, 2008; Chi and Pan, 2001)	N (Landcare Research, 2008; PPIN, 2009)	N						No
Monilinia fructigena Honey	spur canker	Y (CPC, 2007)	Y (Fan *et al*, 2007)	N (Landcare Research, 2008; PPIN, 2009)	N						Yes
Mycosphaerella angulata (Aanamorph: *Cercospora brachypus*)	angular leaf spot of muscadines	N (Jenkins, 1941)	Y (Farr *et al*, 2008)	N (Landcare Research, 2008; PPIN, 2009)	N						No
Phakopsora ampelopsidis Dietel & P. Sydow, 1898	Ampelopsis rust fungus	N (CPC, 2007)	Y (Farr *et al*, 2008; CABI, 2009; Papademetriou and Dent, 2001)	N (Landcare Research, 2008; PPIN, 2009)	N						No
Phakopsora euvitis Y. Ono	grape rust	N¢ (CPC, 2007)	Y (CABI, 2007; Farr *et al*, 2008)	N (Landcare Research, 2008; PPIN, 2009)	N						No
Phymatotrichopsis omnivora (Duggar) Hennebert 1916	grapevine Texas root rot	N (Kuhn, 1981)	Y (Farr *et al*, 2008)	N (Landcare Research, 2008; PPIN, 2009)	N						No
Plasmopara viticola (Berk.et Curtis) Berl. de Toni	Downey mildew	Y (CPC, 2007; Kennelly *et al*, 2005)	Y (Farr *et al*, 2008; Chen *et al*, 2007; Sha *et al*, 2007; Papademetriou and Dent, 2001)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No

Scientific name and Authority	Common name	Commodity association (see note 1)	Present in China (reference) (see note 2)	Present in NZ (reference) (see note 3)	Vect-or	In NZ but associat-ion with goods increases hazard	In NZ but geogra-phically bounded	In NZ but has different host associations or strains	No or little informat-ion on organism	Under official control or notifiable	Potent-ial hazard
Pseudocercospora vitis (Lev.) Sawada (*Mycosphaerella personata*)	grapevine leaf spot	N (AQSIQ, 2007)	Y (AQSIQ, 2007; Papademetriou and Dent, 2001)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No
Pseudopezicula tetraspora	Angular leaf scorch	Y (Pearson *et al*, 1988)	N (Pearson *et al*, 1988)	N (Landcare Research, 2008; PPIN, 2009)	N						No
Rosellinia necatrix Berlese Prillieux	dematophora root rot	N (Kawai *et al*, 1986)	Y (Farr *et al*, 2008; Cai *et al*, 2005; UK, 1976c)	Y (Landcare Research, 2008; PPIN,2009)	N	No	No	No	No	No	No
Uncinula necator (Schw) Burr	Powdery mildew	Y (CPC, 2007; Pearson and Goheen, 1988)	Y (Farr *et al*, 2008; Pan, 1994; Zhu *et al*, 2005; Papademetriou and Dent, 2001)	Y (Landcare Research, 2008; PPIN, 2009)	N	No	No	No	No	No	No
Insects											
Acrothinium gaschkevitschii Motschulsky	shining leaf beetle	N (AQSIQ, 2007)	Y (AQSIQ, 2007; Zhang *et al*, 2008)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; PPIN, 2009)	N						No
Adalia bipunctata Linnaeus, 1758	twospotted ladybird	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (Scott and Emberson, 1999; Scott and Emberson, 1999; PPIN, 2009)	N						No
Adoretus sinicus Burmeister, 1855 (syn. *Adoretus tenuimaculatus* Waterhouse, 1875)	Chinese Rose Beetle, chestnut brown chafer	N (AQSIQ, 2007)	Y (AQSIQ, 2007; CPC, 2007; UK, 1981)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; CPC, 2007; PPIN, 2009)	N						No

Scientific name and Authority	Common name	Commodity association (see note 1)	Present in China (reference) (see note 2)	Present in NZ (reference) (see note 3)	Vect-or	In NZ but associat-ion with goods increases hazard	In NZ but geogra-phically bounded	In NZ but has different host associations or strains	No or little informat-ion on organism	Under official control or notifiable	Potent-ial hazard
Agrypnus variabilis Candèze 1857	sugarcane wireworm	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (Scott and Emberson, 1999; PPIN, 2009; East and Watson, 1978; Williams and Galbreath, 1987)	N						No
Aleurocanthus woglumi Ashby, 1915	citrus blackfly, blue grey fly, citrus spring whitefly	N (CPC, 2007)	Y (Luo and Zhou, 2000; UK, 1976a; CPC, 2007)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; CPC, 2007; PPIN, 2009)	N						No
Ampelophaga rubiginosa Bremer and Grey, 1852		N (AQSIQ, 2007; CPC, 2007)	Y (AQSIQ, 2007; Papademetriou and Dent, 2001; Papademetriou and Dent, 2001)	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						No
Anomala cuprea (Hope)	oriental beetle	Y (Plant Health Australia, 2006)	N (CPC, 2007)	N (Macfarlane *et al*, 2000; CPC, 2007; PPIN, 2009)	N						No
Anomoneura mori		N (AQSIQ 2009)	Y (AQSIQ 2009)	N (PPIN, 2009)							No
Anoplophora chinensis (Forster, 1771)	black and white citrus longhorn	N (EPPO, 2007)	Y (CABI, 2008; Caroulle, 2008; CPC, 2007)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; CPC, 2007; PPIN, 2009)	N						No

Scientific name and Authority	Common name	Commodity association (see note 1)	Present in China (reference) (see note 2)	Present in NZ (reference) (see note 3)	Vect-or	In NZ but associat-ion with goods increases hazard	In NZ but geogra-phically bounded	In NZ but has different host associations or strains	No or little informat-ion on organism	Under official control or notifiable	Potent-ial hazard
Aonidiella aurantii (Coquillett, 1891)	citrus red scale	N (CPC, 2007) *(MAFBNZ, 2008; EPPO, 2007)	Y (UK, 1975a; Wang, 1992; CPC, 2007)	Y (Scott and Emberson, 1999; Spiller and Wise, 1982; Charles and Henderson, 2002; PPIN, 2009)	N						No
Aonidiella citrina (Coquillett, 1891)	citrus yellow scale	N (EPPO, 2007; CPC, 2007)	Y (Shi *et al*, 2006; UK, 1997; CPC, 2007)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; CPC, 2007; PPIN, 2009)	N						No
Aphis craccivora Koch, 1854	groundnut aphid	N (CPC, 2007) *(MAFBNZ, 2008)	Y {(Li *et al*, 2005; Liu *et al*, 2005; CPC, 2007)	Y (Scott and Emberson, 1999; Spiller and Wise, 1982; CPC, 2007; PPIN, 2009)	Y[v]						No
Aphis fabae Scopoli, 1763	black bean aphid	N (CPC, 2007; Ingels *et al*, 1998)	Y (Liu *et al*, 2005; UK, 1963; CPC, 2007)	N (Scott and Emberson, 1999; Teulon *et al*, 2004; CPC, 2007; PPIN, 2009)	Y[v]						No
Aphis gossypii Glover, 1877	cotton aphid	N (CPC, 2007) *(MAFBNZ, 2008)	Y (Liu *et al*, 2005; CPC, 2007)	Y (Teulon *et al*, 2004; Charles, 1998; CPC, 2007; PPIN, 2009)	Y[v]						No
Apolygus lucorum (Meyer-Dur, 1843) (syn. *Lygus lucorum*; *Lygocoris lucorum)*	green plant bug	Y (Liu *et al*, 2004b)	Y (AQSIQ, 2007; Lu *et al*, 2009; CPC, 2007)	N (PPIN, 2009; CPC, 2007)	N						Yes

Scientific name and Authority	Common name	Commodity association (see note 1)	Present in China (reference) (see note 2)	Present in NZ (reference) (see note 3)	Vect-or	In NZ but associat-ion with goods increases hazard	In NZ but geogra-phically bounded	In NZ but has different host associations or strains	No or little informat-ion on organism	Under official control or notifiable	Potent-ial hazard
Arboridia apicalis (Nawa, 1913) (syn. *Erythroneura apicalis*; *Zygina apicalis*)	grape leafhopper	N (USapple.org, 2003)	Y (FAO, 2007; Ma *et al*, 2004)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; PPIN, 2009)	Y[v]						No
Arcte coerula Guenée, 1852	fruit piercing moth	N (CPC, 2007)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009; Hoare, 2001); i record from Auckland (Dugdale, 1988)	N						No
Argyrotaenia citrana Fernald, 1889	orange tortrix	Y (Kido *et al*, 1981)	N (CPC, 2007)	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						No
Bactrocera dorsalis (Hendel, 1912)	oriental fruit fly	Y (EPPO, 2007; Chu and Tung, 1996)	Y (CPC, 2007; Ren *et al*, 2008a)	N (Macfarlane *et al*, 2000; CPC, 2007; PPIN, 2009)	N						Yes
Blastobasis tarda Meyrick 1902		N *(MAFBNZ, 2008)	N (Li, 2008)	Y (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						No
Blattella germanica (Linnaeus, 1767)	german cockroach	N (CPC, 2007) *(MAFBNZ, 2008)	Y (Ren *et al*, 2008c, Yang *et al*, 2008)	Y (Helson, 1971; ESNZ, 1977; PPIN, 2009)	N						No
Bromius obscurus (Linnaeus, 1758) (syn. *Adoxus obscurus*)	leaf beetle	N (AQSIQ, 2007; Schneider, 1945)	Y (AQSIQ, 2007; Li and Li, 2007)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; PPIN, 2009)	N						No
Byctiscus lacunipennis Voss, 1930		N (AQSIQ, 2007)	Y (AQSIQ, 2007)	N (PPIN, 2009)	N						No

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Cadra cautella Walker 1863 (syn. *Ephestia cautella*)	dried currant moth	N (CPC, 2007) *(MAFBNZ, 2008)	Y (Luo *et al*, 1983; CPC, 2007)	Y (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						No
Cadra figulilella Gregson 1871	raisin moth	Unknown (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						No
Calyptra lata Butler (syn. *Oraesia lata*)	fruit-piercing moth	Y (AQSIQ, 2009)	Y (AQSIQ, 2007)	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N				Yes		Yes
Carpophilus davidsoni Dobson, 1952	Australian sap beetle	N *(MAFBNZ, 2008)	N	Y (PPIN, 2009)	N						No
Carpophilus hemipterus (Linnaeus, 1758)	dried fruit beetle	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (ESNZ, 1977; Archibald and Chalmers, 1983; PPIN, 2009)	N						No
Carpophilus ligneus Murray, 1864		N *(MAFBNZ, 2008)	N	N (Scott and Emberson, 1999; PPIN, 2009)	N						No
Carpophilus obsoletus Erichson, 1843	corn sap beetle	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; CPC, 2007) Intercepted (Archibald and Chalmers, 1983)	N						No
Carystoterpa fingens Walker, 1851	spittle bug	N *(MAFBNZ, 2008)	N	Y (PPIN; Syrett and Smith, 1998)	N						No

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Cecidomyia sp.	midges	N (Gagne, 1978; Quaintance and Shear, 1921)	Y (Qi and Guo, 1987; Wen JunBao *et al*, 1998; Wu *et al*, 1989)	Y (Macfarlane *et al*, 2000; PPIN, 2009)	N						No
Cicadella viridis Linnaeus (syn. *Tettigella viridis*)		N	Y (AQSIQ 2007b)	N (Spiller & Wise 1982; Scott & Emberson 1999; PPIN 2009)	No						No
Coccinella transversalis Fabricius	transverse Ladybird	Indirect *(MAFBNZ, 2008)	Y (CPC, 2007; Ades and Kendrick, 2004)	N (PPIN, 2009)	N						Yes
Coleophora inaequalis F.	common Australian lady beetle	N *(MAFBNZ, 2008)	N	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						No
Conogethes punctiferalis Guenee (syn. *Dichocrocis punctiferalis*)	yellow peach moth, castor capsule borer	Y (AQSIQ, 2007; CPC, 2007)	Y (AQSIQ, 2007; FAO, 2007; CPC, 2007;)	N (PPIN, 2009; Dugdale, 1988)	N						Yes
Corticaria serrata Payk.	mould beetle	N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Corythucha ciliata (Say, 1832)	sycamore lace bug	N (CPC, 2007) *(MAFBNZ, 2008)	Y (Li *et al*, 2007; Kim and Jeong, 1999)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; PPIN, 2009)	N						No
Cryptoblabes gnidiella Millière 1867	citrus pyralid	Y (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (Dugdale, 1988)	Y[v]						No

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Cryptophagus cellaris	silken fungus Beetle	N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Dacne fungorum Lewis,1887	fungus beetle	N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Dictyotus caenosus	brownshield bug	N *(MAFBNZ, 2008)	N	Y (PPIN, 2009; Wightman and Macfarlane, 1982)	N						No
Drepanothrips reuteri Uzel, 1895	vine thrips	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; PPIN, 2009)	N						No
Drosophila melanogaster Meigen, 1830	common fruit fly	Y (Capy *et al*, 1987) *(MAFBNZ, 2008)	Y (Jiang *et al*, 1989; Luo and Zhuang, 2007; Wang and Ma, 2008)	Y (PPIN, 2009; Macfarlane *et al*, 2000)	Y[v]						No
Drosophila suzukii (Matsumura)	spotted wing Drosophila	Y (ODA, 2009; Kanzawa, 1939)	Y (Wu *et al*., 2007 ODA, 2009; USU, 2009)	N (Macfarlane *et al*, 2000; PPIN, 2009)	No						Yes
Empoasca vitis Gothe, 1875	smaller green leafhopper	N (CPC, 2007)	Y (CPC, 2007; Han *et al*, 2009; Fu and Han, 2007)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; PPIN, 2009; CPC, 2007)	N						No
Epiphyas postvittana Walker 1863	light brown apple moth	Y (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	Y[v]						No

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Eriopis connexa	lady beetle	Indirect (Curkovic *et al*, 1995) *(MAFBNZ, 2008)	N (CPC, 2007)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; PPIN, 2009; CPC, 2007)	N						No
Erythroneura elegantula Osborne 1928	grape leafhopper	Y (Jensen *et al*, 1969) *(MAFBNZ, 2008)	N (CPC, 2007)	N (Scott and Emberson, 1999; Spiller and Wise, 1982; ESNZ, 1977; PPIN, 2009)	N						No
Estigmene acrea Drury 1770	saltmarsh caterpillar	N *(MAFBNZ, 2008)	N	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						No
Eudocima fullonia (Clerck, 1764) (syn. *Ophideres fullonica*)	fruit-sucking moth	Y (Hanken, 2000 (revised 2002))	Y (Park *et al*, 1988; Cai and Geng, 1997)	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						Yes
Eudocima tyrannus Guenee 1852 (syn. *Adris tyrannus*)	fruit-piercing moth	Y (Hanken, 2000 (revised 2002))	Y (AQSIQ, 2007; Ades and Kendrick, 2004)	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						Yes
Eupoecilia ambiguella Walsingham 1900	grapevine moth	Y (Marcelin, 1985)	Y (CPC, 2007; AgroAtlas, 2008; UK, 1986a)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						Yes
Euschistus conspersus Uhler, 1879	Consperse stink bug	Y (Plant Health Australia, 2006)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009)	N						No
Forficula auricularia Linnaeus, 1758	European earwig	Indirect *(MAFBNZ, 2008)	N (CPC, 2007)	Y (CPC, 2007; PPIN, 2009)	N						No

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Formica rufa Linnaeus, 1761	red ant	N *(MAFBNZ, 2008)	N (CPC, 2007)	N (Berry, 2007; CPC, 2007; PPIN, 2009)	N						No
Frankliniella occidentalis (Pergande, 1895)	Western flower thrips	Y (CPC, 2007) *(MAFBNZ, 2008)	Y (Nakahara, 1997; Liang *et al*, 2007)	Y (Nakahara, 1997; PPIN, 2009; Scott and Emberson, 1999)	Y[v]	No	No	No	No	No	No
Gastrimargus marmoratus (Thunberg 1815)	marbled grasshopper http://www.planthealthaustralia.com.au/project_documents/tst/viewTST.asp?page=12&ID=134&print=true&filter=1&records=10&sort=7&order=1 - Locu	N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Halyomorpha halys Stal 1855	brown marmorated stink bug	N[$] (Wermelinger *et al*, 2008)	Y (Rider and Zheng, 2005)	N (Lariviere & Larochelle, 2004; PPIN 2009)	N						No
Haptoncus luteolus (Erichson, 1843)	sap beetle	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; Li, 1981)	N (PPIN, 2009)	N						No
Harmonia axyridis (Pallas, 1773)	harlequin ladybird	Y (CPC, 2007)	Y (CPC, 2007; Koch, 2003; Li *et al*, 2008)	N (PPIN, 2009; Scott and Emberson, 1999; Spiller and Wise, 1982)	N						Yes

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Harrisina americana Guérin-Meneville 1829/44	skeletonizer grape leaf	N (Mead, 1970) *(MAFBNZ, 2008)	N (CPC, 2007)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Harrisina metallica Stretch 1885 (syn. *Harrisina brillians*)	Western Grape Leaf Skeletonizer	Y (Stern *et al*, 1980) *(MAFBNZ, 2008)	N	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Heliothrips haemorrhoidalis (Bouché, 1833)	black tea thrips	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; UK, 1961)	Y (CPC, 2007; PPIN, 2009)	N						No
Hemiberlesia lataniae (Signoret, 1869)	latania scale	Y (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; UK, 1976b)	Y (CPC, 2007; PPIN, 2009)	N	No	No	No	No	No	No
Hemiberlesia rapax (Comstock, 1881)	Camellia scale	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (CPC, 2007; PPIN, 2009)	N						No
Hemideina thoracica (White, 1846)	common tree weta	N *(MAFBNZ, 2008)	N	Y (PPIN, 2009)	N						No
Hippodamia convergens Guérin-Méneville, 1842	convergent lady beetle	Indirect *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Hippotion celerio Linnaeus 1758	taro hawkmoth	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; Ades and Kendrick, 2004; Pittaway and Kitching, 2003)	Y (PPIN, 2009); Non-establishing (Dugdale, 1988)	N						No
Holotrichia oblita (Faldermann)	scarab	N (AQSIQ, 2007)	Y (AQSIQ, 2007; CPC, 2007; Luo *et al*, 2008)	N (PPIN, 2009; CPC, 2007)	N						No

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Homalodisca coagulata	glassy winged sharpshooter	Y (CPC, 2007)	N (CPC, 2007)	N (PPIN, 2009; CPC, 2007)	Y[v]						No
Hyles lineata Fabricius 1775	white-lined sphinx	N (Kharizanov, 1978)	N (CPC, 2007)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Hypera postica Germar, 1821	lucerne weevil	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; Bai *et al*, 1990)	N (PPIN, 2009; CPC, 2007)	Y[v]						No
Hypera variabilis Dejean, 1821	alfalfa weevil	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007)	N (PPIN, 2009; CPC, 2007)	N						No
Hyphantria cunea Drury 1770	mulberry moth	Y (Brunner and Zack, 1993)	Y (CPC, 2007; Warren and Tadic, 1970)	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						Yes
Illiberis tenuis Butler 1877	grape leaf worm	N (AQSIQ, 2007)	Y (AQSIQ, 2007)	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						No
Irenimus aequalis (Broun)	weevil	N *(MAFBNZ, 2008)	N	Y (PPIN, 2009)	N						No
Laius bellulus (Guerin)		N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Leptoglossus gonagra (Fabricius, 1775)	squash bug	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007)	N (PPIN, 2009; CPC, 2007)	Y[v]						No
Linepithema humile (Mayr, 1868)	Argentine ant	Indirect (Daane *et al*, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (Berry, 2007; PPIN, 2009; CPC, 2007)	N						No

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Listroderes costirostris Schoenherr, 1823	vegetable weevil	N (CPC, 2007) *(MAFBNZ, 2008)	N	Y (PPIN, 2009; CPC, 2007)	N						No
Lobesia botrana Denis & Schiffermüller, 1775	grape berry moth	Y (Plant Health Australia, 2006) (CPC, 2007)	N (CPC, 2007)	N (Dugdale, 1988; Hoare, 2001; PPIN, 2009)	N						No
Lycorma delicatula (White, 1845)	lantern fly	N (AQSIQ, 2007)	Y (AQSIQ, 2007; Ding *et al*, 2004)	N (PPIN, 2009)	N						No
Maconellicoccus hirsutus (Green, 1908)	pink hibiscus mealybug	Y (CPC, 2007)	Y (CPC, 2007; UK, 2004b)	N (PPIN, 2009; CPC, 2007)	N						Yes
Mamestra brassicae Linnaeus, 1758	cabbage moth	Y (CPC, 2007; Voigt, 1974)	Y (CPC, 2007; UK, 1984)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						Yes
Melanophthalma Motschulsky Herbst, 1793		N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Merhynchites sp.		Y+ (AQSIQ, 2009)	Y (AQSIQ, 2007)	N (May, 1993; PPIN, 2009)	N				Yes		No
Micromus tasmaniae (Walker, 1860)	tasmanian lacewing	N (PPIN, 2009) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (PPIN, 2009)	N						No
Monomorium destructor (Jerdon, 1851)	singapore ant	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	N (Berry, 2007; PPIN, 2009; CPC, 2007)	N						No
Naupactus leucoloma Boheman, 1840	whitefringed weevil	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (PPIN, 2009; CPC, 2007)	N						No

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Nippoptilia vitis Sasaki, 1913		Y (AQSIQ, 2007)	Y (AQSIQ, 2007; Zheng *et al*, 1993; Zheng *et al*, 1993)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						Yes
Notoncus ectatommoides (Forel, 1892)	pronged epaulet ants	N *(MAFBNZ, 2008)	N	N (Berry, 2007; PPIN, 2009)	N						No
Nysius clevelandensis Evans, 1929	grey cluster bug	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	N (Lariviere; PPIN, 2009; CPC, 2007)	N						No
Ochetellus glaber (Mayr, 1862)	black house ant	N *(MAFBNZ, 2008)	N	Y (Berry, 2007; PPIN, 2009)	N						No
Oecanthus indicus Saussure, 1878	tree cricket	N (AQSIQ, 2007)	Y (AQSIQ, 2007; Xie and Zheng, 2001)	N (PPIN, 2009)	N						No
Oides decempunctata Billberg, 1808	grape leaf beetle	N (AQSIQ, 2007)	Y (AQSIQ, 2007; Hoffmann, 1932; Papademetriou and Dent, 2001)	N (PPIN, 2009)	N						No
Oides tarsata Baly, 1865	grape yellow leaf beetle	N (AQSIQ, 2007)	Y (AQSIQ, 2007)	N (PPIN, 2009)	N						No
Onthophagus tweedensis Blackburn, 1903	dung beetle	N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Opifex fuscus Hutton, 1902	saltpool mosquito	N *(MAFBNZ, 2008)	N	Y (PPIN, 2009)	N						No
Oraesia emarginata Fabricius, 1794	fruit piercing moth	Y (AQSIQ, 2007; Hanken, 2000 (revised 2002))	Y (AQSIQ, 2007; CPC, 2007; Ades and Kendrick, 2004)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						Yes

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Oraesia excavata Butler, 1878	fruit-piercing moth	Y (AQSIQ, 2007; Hanken, 2000 (revised 2002))	Y (AQSIQ, 2007; CPC, 2007; Ades and Kendrick, 2004)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						Yes
Orgyia postica Walker, 1855	cocoa tussock moth	N (CPC, 2007)	Y (CPC, 2007; Ades and Kendrick, 2004; UK, 2000b)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Otiorhynchus corruptor Gistel, 1848	root weevil	N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Otiorhynchus rugostriatus Goeze, 1877	rough strawberry root weevil	N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Otiorhynchus sulcatus Germar, 1824	black vine weevil	Y (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (May, 1993; PPIN, 2009)	N						No
Oxydema longulum (Boheman, 1859)	Oxydema weevil	N *(MAFBNZ, 2008)	N	N (PPIN, 2009)	N						No
Pachybrachius inornatus (Walker, 1872)	weed seed bug	N *(MAFBNZ, 2008)	N	N (Lariviere; PPIN, 2009)	N						No
Pantomorus cervinus (Boheman, 1840)	Fuller's rose beetle	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (PPIN, 2009; CPC 2007)	N						No
Paranthrene regalis Butler	grape clearwing moth	N (AQSIQ, 2007)	Y (AQSIQ, 2007; Zhou, 1995; Hu, 1986; Papademetriou and Dent, 2001)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Parthenolecanium corni (Bouche 1844)	European fruit lecanium	N (AQSIQ, 2007; Yang *et al*, 2005b)	Y (AQSIQ, 2007; Yang *et al*, 2005b; UK, 1999a)	Y (PPIN, 2009; CPC 2007)	Y[v]						No

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Parthenolecanium persicae (Fabricius, 1776)	peach scale	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; Cui *et al*, 1997)	Y (PPIN, 2009; CPC 2007)	N						No
Peridroma saucia (Hübner, 1808)	pearly underwing moth	Y (Dibble *et al*, 1979; CPC, 2007)	Y (CPCI 2007; Kuang 1985)	N (Dugdale 1988, Hoare 2001, PPIN 2009)	N						Yes
Phalaenoides glycinae Lewin, 1805	vine moth	Y (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	N (PPIN, 2009; CPC, 2007)	N						No
Phlyctinus callosus Boheman	vine calandra	Y (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (May, 1993; PPIN, 2009; CPC, 2007)	N						No
Pieris rapae Linnaeus, 1758	cabbage white butterfly	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; UK, 1952a, He *et al*, 2005)	Y (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Pinnaspis strachani (Cooley, 1899)	Hibiscus snow scale	Y (Tenbrick *et al*, 2007; CPC, 2007)	Y (CPC, 2007; Watson, 2006)	N (PPIN, 2009; CPC, 2007)	N						Yes
Planococcus citri (Risso, 1813)	grape mealybug	Y (CPC, 2007)	Y (CPC, 2007; UK, 1999b)	Y (PPIN, 2009; CPC, 2007)	Y[v]	No	No	No	No	No	No
Plautia stali Scott	stink bug	Y (Schaefer and Panizzi, 2000)	Y (Mau and Mitchell, 1978; Liu and Zheng, 1994)	N (Larivière and Larochelle, 2004) (PPIN, 2009; CPC, 2007)	N						Yes
Plutella xylostella Linnaeus 1767	diamondback moth	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; UK, 1967; Wang *et al*, 2008)	Y (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No

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Polistes chinensis (Fabricius, 1793)	asian paper wasp	Indirect, *(MAFBNZ, 2008)	Y (CPC, 2007; She and Feng, 2008)	Y (PPIN, 2009; CPC, 2007)	N	N	N	N	N	N	No
Popillia japonica	Japanese beetle	N (CPC, 2007)	Y (CPC, 2007; EPPO, 2006; UK, 1952b)	N (PPIN, 2009; CPC, 2007)	N						No
Proeulia chrysopteris Butler, 1883	fruit leaf folder	Y (CPC, 2007)	N (CPC, 2007)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Protaetia brevitarsis Lewis, 1879)	white-spotted flower chafer	N (AQSIQ, 2007)	Y (AQSIQ, 2007; Zhang *et al*, 2008)	N (PPIN, 2009)	N				Y		No
Proteuxoa comma Walker, 1856		N *(MAFBNZ, 2008)	N	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Pseudococcus calceolariae (Maskell, 1879)	scarlet mealybug	Y (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; Ben-Dov *et al*, 2006)	Y (CPC, 2007; PPIN, 2009; Ben-Dov *et al*, 2006)	Y[v]						No
Pseudococcus longispinus (Targioni Tozzetti, 1867)	long-tailed mealybug	Y (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; Ben-Dov *et al*, 2006)	Y (CPC, 2007; PPIN, 2009; Ben-Dov *et al*, 2006)	Y[v]						No
Pseudococcus maritimus (Ehrhorn, 1900)	grape mealybug	Y (Grimes and Cone, 1985)	Y (AQSIQ, 2007; CPC, 2007; Abudujapa and Sun, 2007)	N (Cox, 1977; CPC, 2007; PPIN, 2009; Ben-Dov *et al*, 2006)	Y						Yes
Pseudococcus viburni (Signoret, 1875)	Californian mealybug	Y (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (PPIN, 2009; CPC, 2007)	Y[v]						No

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Quadraspidiotus perniciosus (syn. *Diaspidiotus perniciosus*)	Chinese scale	Y (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; UK, 1986b, Yang *et al*, 2005a)	Y (Charles and Henderson, 2002; PPIN, 2009; CPC, 2007)	N	N	N	N	N	N	No
Reesa vespulae (Milliron, 1939)		N *(MAFBNZ, 2008)	N	Y (PPIN, 2009; Waller, 1982)	N						No
Rhipiphorothrips cruentatus Hood, 1919	grapevine thrips	Y (Batra *et al*, 1986; Kulkarni *et al*, 2007)	Y (CPC, 2007; Zhang, 1980)	N (PPIN, 2009; Mound and Walker, 1982)	N						Yes
Rhytidoponera metallica (Smith, 1858)	green-head ants	N *(MAFBNZ, 2008)	N	Y (Berry, 2007; PPIN, 2009)	N						No
Saissetia oleae (Olivier, 1791)	olive scale	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; UK, 1952c)	Y (PPIN, 2009; CPC, 2007)	N						No
Sarbanissa subflava Moore, 1877 (syn. *Seudyra subflava*)	boston ivy tiger-moth	N (AQSIQ, 2007)	Y (AQSIQ, 2007; Liu, 1941; Papademetriou and Dent, 2001)	N (PPIN; Dugdale, 1988; Hoare, 2001)	N						No
Scelodonta lewisii Baly, 1874		N (AQSIQ, 2007; Chen, 1940)	Y (AQSIQ, 2007; Chen, 1940)	N (PPIN, 2009)	N						No
Scirtothrips dorsalis Hood, 1919	chilli thrips	Y (Ali *et al*, 1973)	Y (CPC, 2007; Li *et al*, 2004; UK, 1986c)	N (CPC, 2007; PPIN, 2009; Mound and Walker, 1982)	N						Yes
Scirtothrips mangiferae Priesner, 1932	mango thrips	Y (Plant Health Australia, 2006)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009)	N						No

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Sinoxylon sp.	grape bostrichid	N (AQSIQ, 2007; Ragazzini, 1977)	Y (AQSIQ, 2007; Luo and Wu, 1998)	N (PPIN, 2009)	N						No
Sitona discoideus Dejean	sitona weevil	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (CPC, 2007; PPIN, 2009)	N						No
Sitona humeralis Stephens, 1831	Clover weevil	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009)	N						No
Spirama retorta Clerck, 1764		Y (Hanken, 2000 (revised 2002)), Kim and Lee, 1985)	Y (Nair, 2007; Ades and Kendrick, 2004)	N (PPIN, 2009; Hoare, 2001; Dugdale, 1988)	N						Yes
Sylvicola notatus Hutton, 1902		N *(MAFBNZ, 2008)	N	Y (Macfarlane *et al*, 2000; PPIN, 2009)	N						No
Technomyrmex albipes (Smith, 1861)	white-footed ant	N (CPC, 2007) *(MAFBNZ, 2008)	N (CPC, 2007)	Y (Berry, 2007; CPC, 2007; PPIN, 2009)	N						No
Tenothrips frici (Uzel, 1895)	dandelion thrips	N *(MAFBNZ, 2008)	N	Y (PPIN, 2009)	N						No
Theretra oldenlandiae Fabricius, 1775	hawkmoth	N (CPC, 2007)	Y (CPC, 2007; Ades and Kendrick, 2004)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Thrips tabaci Lindeman, 1889	potato thrips	N (CPC, 2007; AQSIQ, 2007)	Y (CPC, 2007; AQSIQ, 2007)	Y (CPC, 2007; PPIN, 2009; Scott and Emberson, 1999)	Y[v]						No

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Trichoplusia ni Hübner, 1802	cabbage looper	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CABI/EPPO (328), 1974; CPC, 2007; Ades and Kendrick, 2004)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No
Trigonospila brevifacies (Hardy)	Australian leafroller tachinid	N *(MAFBNZ, 2008)	N (CPC, 2007)	Y (Macfarlane *et al*, 2000; CPC, 2007; PPIN, 2009)	N						No
Urophorus humeralis (Fabricius, 1798)	pineapple sap beetle	Y (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007)	Y (PPIN, 2009; CPC, 2007)	N	No	No	No	No	No	No
Vespa mandarinia Smith, 1852	Japanese hornet	N	Y (AQSIQ, 2007; Wang *et al*, 1985)	N (Berry, 2007; PPIN, 2009)	N						No
Viteus vitifoliae (Fitch, 1855) (syn. *Daktylosphaera vitifoliae*)	grapevine phylloxera	N (CPC, 2007)	Y (CPC, 2007; Galet *et al*, 1980; UK, 1975b)	Y (CPC, 2007; UK, 1975b)	N						No
Xestia c-nigrum (Linnaeus, 1758)	spotted cutworm	Y (CPC, 2007)	Y (CPC, 2007; UK, 1979)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						Yes
Xylotrechus pyrrhoderus Bates, 1873	grape borer	N (AQSIQ, 2007)	Y (AQSIQ, 2007; Chien, 1989; Papademetriou and Dent, 2001)	N (PPIN, 2009)	N						No
Zelus exsanguis Stål, 1862	assassin Bug	N *(MAFBNZ, 2008)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009)	N						No
Zeuzera coffeae Nietner, 1861	coffee leopard moth	N (CPC, 2007)	Y (CPC, 2007; Ades and Kendrick, 2004)	N (PPIN, 2009; Dugdale, 1988; Hoare, 2001)	N						No

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Arthropods											
Achaearanea veruculata Urquhart, 1886	cobweb spider	N *(MAFBNZ, 2008)	N	Y (Forster and Forster, 1999; PPIN, 2009)	N						No
Anystis baccarum (Linne)	whirligig mite	N (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007; Ming *et al*, 1983)	Y (PPIN, 2009; CPC, 2007)	N						No
Badumna insignis (Koch, 1872)	black house spider	N *(MAFBNZ, 2008)	N	Y (Forster and Forster, 1999)	N						No
Badumna longinqua (Koch, 1867)	brown house spider	Indirect*(MAF BNZ, 2008)	N	Y (Forster and Forster, 1999; PPIN, 2009; Reed and Newland, 2002)	N						No
Brevipalpus californicus (Banks, 1904)	citrus flat mite	Y (CPC, 2007) *(MAFBNZ, 2008)	Y (CPC, 2007)	Y (PPIN, 2009; CPC, 2007)	Y[v]	No	No	No	No	No	No
Brevipalpus lewisi McGregor, 1949	citrus flat mite	Y (Kerns *et al*, Elmer and Jeppson, 1956)	Y (AQSIQ, 2007; Papademetriou and Dent, 2001)	(PPIN, 2009; Manson, 1987; Ramsay, 1980)	N						Yes
Bryobia praetiosa Koch, 1836	clover mite	N	N (CPC, 2007)	Y (PPIN, 2009; CPC, 2007)	N						No
Cheiracanthium inclusum (Hentz, 1847)	Yellow Sac Spider	Indirect (Reed and Newland, 2002) *(MAFBNZ, 2008)	N (CPC, 2007)	N (Forster and Forster, 1999; PPIN, 2009; CPC, 2007; Reed and Newland, 2002)	N						No

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Cheiracanthium stratioticum Koch, 1873	slender sac spider	Indirect *(MAFBNZ, 2008)	N	Y (Forster and Forster, 1999; PPIN, 2009; Reed and Newland, 2002)	N						No
Colomerus vitis (Pagenstecher, 1857)	grape gall mite	N (AQSIQ, 2007; CPC, 2007) *(MAFBNZ, 2008)	Y (AQSIQ, 2007; Papademetriou and Dent, 2001)	Y (PPIN, 2009; CPC, 2007)	Y[v]						No
Dysdera crocata Koch, 1838	garden spider	Indirect (Reed and Newland, 2002) *(MAFBNZ, 2008)	Y (Li, 2008)	Y (Forster and Forster, 1999; PPIN, 2009)	N	No	No	No	No	No	No
Eotetranychus carpini vitis		N (CPC, 2007)	N (CPC, 2007)	N (Migeon and Dorkeld, 2006; PPIN, 2009; CPC, 2007)	N						No
Eotetranychus carpini (Oudemans, 1905)	yellow spider mite	N (CPC, 2007)	Y (Migeon and Dorkeld, 2006; Ma and Yuan, 1981)	N (Migeon and Dorkeld, 2006; PPIN, 2009; CPC, 2007)	N						No
Eotetranychus geniculatus Ehara, 1969		N	Y (Migeon and Dorkeld, 2006)	N (Migeon and Dorkeld, 2006; PPIN, 2009)	N						No
Eotetranychus kankitus Ehara, 1955	miyake spider mite	N (CPC, 2007)	Y (Migeon and Dorkeld, 2006; CPC, 2007)	N (Migeon and Dorkeld, 2006; PPIN, 2009; CPC, 2007)	N						No

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Eotetranychus pruni (Oudemans, 1931)	apple yellow mite	N (AgroAtlas, 2009)	Y (Migeon and Dorkeld, 2006; CPC, 2007)	N (Migeon and Dorkeld, 2006; Migeon and Dorkeld, 2006; PPIN, 2009; CPC, 2007)	N						No
Eotetranychus sexmaculatus (Riley, 1890)	six-spotted spider mite	N (Zhang, 2003)	Y (Migeon and Dorkeld, 2006; CPC, 2007)	Y (Migeon and Dorkeld, 2006; PPIN, 2009)	N						No
Eotetranychus smithi Pritchard & Baker, 1955	Smith spider mite	N	Y (Migeon and Dorkeld, 2006; Wang, 1980)	N (Migeon and Dorkeld, 2006; PPIN, 2009)	N						No
Eotetranychus willamettei	willamette mite	N (University of California, 2008)	N (Migeon and Dorkeld, 2006; CPC, 2007)	N (Migeon and Dorkeld, 2006; CPC, 2007; PPIN, 2009)	N						No
Eupalopsis jamesi Gerson		N *(MAFBNZ, 2008)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009)	N						No
Eutetranychus orientalis (Klein, 1936)	Citrus brown mite	N (CPC, 2007)	Y (Migeon and Dorkeld, 2006; CPC, 2007)	N (Migeon and Dorkeld, 2006; CPC, 2007; PPIN, 2009)	N						No
Hypoblemum albovittatum (Keyserling, 1882)	jumping spider	N (Minor, 2006)*(MAFB NZ, 2008)	N	Y (Minor, 2006; PPIN, 2009)	N						No
Isopedella cerussata (Simon, 1908)	huntsman spider	N *(MAFBNZ, 2008)	N	N (Forster and Forster, 1999; PPIN, 2009)	N						No
Lampona cylindrata (Koch, 1866)	whitetailed spider	N *(MAFBNZ, 2008)	N	Y (Forster and Forster, 1999; PPIN, 2009; Reed and Newland, 2002)	N						No

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Latrodectus geometricus Koch, 1841	brown widow spider	Indirect (Reed and Newland, 2002) *(MAFBNZ, 2008)	N (CPC, 2007)	N (Forster and Forster, 1999; CPC, 2007; PPIN, 2009)	N						No
Latrodectus hasselti Thorell, 1870	Redback spider	Indirect (Reed and Newland, 2002)*(MAFB NZ, 2008)	Y (Li, 2008)	Y (Forster and Forster, 1999; Forster and Forster, 1999; PPIN, 2009; Reed and Newland, 2002)	N	Yes	Yes	No	No	No	#Yes
Latrodectus hesperus Chamberlin and Ivie, 1935	western black widow	Indirect (Reed and Newland, 2002)*(MAFB NZ, 2008)	N (CPC, 2007)	N (Forster and Forster, 1999; CPC, 2007; PPIN, 2009; Reed and Newland, 2002)	N						No
Latrodectus mactans Urquhart, 1890	black widow spider	Indirect (Reed and Newland, 2002) *(MAFBNZ, 2008)	Y (Li, 2008; Ushkaryov *et al*, 2004)	N (Forster and Forster, 1999; Forster and Forster, 1999; PPIN, 2009)	N						#Yes
Oligonychus biharensis (Hirst, 1924)	cassava red mite	N (CPC, 2007)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009)	N						No
Oligonychus coffeae (Nietner, 1861)	tea red spider mite	N (CPC, 2007)	Y (CPC, 2007; Lu, 1993; Ma and Yuan, 1976)	N (CPC, 2007; PPIN, 2009)	N						No
Oligonychus mangiferus (Rahman & Sapra, 1940)	mango red spider mite	N (CPC, 2007)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009)	N						No

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Oligonychus punicae (Hirst, 1926)	avocado brown mite	N (CPC, 2007)	N (CPC, 2007)	N (CPC, 2007; PPIN, 2009)	N						No
Panonychus citri (McGregor, 1916)	citrus red spider mite	Y (CPC, 2007)	Y (Migeon and Dorkeld, 2006; CPC, 2007)	Y (Migeon and Dorkeld, 2006; CPC, 2007; PPIN, 2009)	N	No	No	No	No	No	No
Panonychus ulmi (Koch, 1836)	European red spider mite	N (CPC, 2007)	Y (Migeon and Dorkeld, 2006; CPC, 2007)	Y (Migeon and Dorkeld, 2006; CPC, 2007; PPIN, 2009)	N						No
Parasteatoda tepidariorum Koch, 1841 (syn. *Achaearanea tepidariorum*)	common house spider	Indirect *(MAFBNZ, 2008)	Y (Li, 2008; Liu *et al*, 2003; Yan *et al*, 2004)	N (Forster and Forster, 1999; PPIN, 2009)	N						#Yes
Petrobia harti (Ewing, 1909)	oxalis spider mite	N	Y (Migeon and Dorkeld, 2006)	N (Migeon and Dorkeld, 2006; CPC, 2007; PPIN, 2009)	N						No
Petrobia latens (Müller, 1776)	brown wheat mite	N (CPC, 2007)	Y (Migeon and Dorkeld, 2006; CPC, 2007)	Y (Migeon and Dorkeld, 2006; PPIN, 2009)	N						No
Phidippus johnsoni Peckham & Peckham, 1883	redbacked jumping spider	Indirect (Reed and Newland, 2002)*(MAFB NZ, 2008)	N	N (Forster and Forster, 1999; PPIN, 2009; Reed and Newland, 2002)	N						No
Phidippus regius Koch, 1846	regal jumping spider	Indirect (Reed and Newland, 2002)*(MAFB NZ, 2008)	N	N (Forster and Forster, 1999; PPIN, 2009; Reed and Newland, 2002)	N						No
Polyphagotarsonemus latus (Banks, 1904)	broad mite	Y (CPC, 2007)	Y (AQSIQ, 2007; CPC, 2007; UK, CAB International Institute of Entomology, 1986)	Y (CPC, 2007; PPIN, 2009)	N	N	N	N	N	N	No

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Sanogasta maculatipes (Keyserling, 1878)		N *(MAFBNZ, 2008)	N	N (Forster and Forster, 1999; PPIN, 2009)	N						No
Sassacus vitis (Cockerell, 1894) (syn. Metaphidippus vitis)	jumping spider	Indirect (Costello and Daane, 1995) *(MAFBNZ, 2008)	N	N (Forster and Forster, 1999; PPIN, 2009)	N						No
Tarsonemus bakeri Ewing, 1939	basswood tarsonomid mite	N *(MAFBNZ, 2008)	N (Lin and Zhang, 1999)	Y (PPIN, 2009)	N						No
Tarsonemus waitei Banks, 1912	peach bud mite	N *(MAFBNZ, 2008)	Y (Lin and Zhang, 1999)	Y (PPIN, 2009)	N						No
Tetranychus kanzawai Kishida, 1927	kanzawa spider mite	Y (CPC, 2007; Ashihara, 1996; Ho and Chen, 1994)	Y (Migeon and Dorkeld, 2006; Takafuji and Hinomoto, 2008)	N (PPIN, 2009; Manson, 1987; Migeon and Dorkeld, 2006)	N						Yes
Tetranychus ludeni Zacher, 1913	red spider mite	N	Y (Ma and Yuan, 1975; Migeon and Dorkeld, 2006)	Y (Migeon and Dorkeld, 2006; PPIN)	N						No
Tetranychus neocaledonicus André, 1933	spider mite	N	Y (Migeon and Dorkeld, 2006; Zhang *et al*, 1990)	N (Zhang, 2007; PPIN 2009)	N						No
Tetranychus piercei McGregor, 1950	Red spider mite	N (CPC, 2007)	Y (Migeon and Dorkeld, 2006; CPC, 2007; Lui and Lui, 1986)	N (Migeon and Dorkeld, 2006; CPC, 2007; PPIN, 2009)	N						No

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Tetranychus truncatus Ehara, 1956	spider mite	N (CPC, 2007)	Y (CPC, 2007; Migeon and Dorkeld, 2006; UK, 1998)	N (Migeon and Dorkeld, 2006; CPC, 2007; PPIN, 2009)	N						No
Tetranychus turkestani (Ugarov and Nikolskii, 1937)	strawberry spider mite	N	Y (Migeon and Dorkeld, 2006; Shi WeiBing *et al*, 2008)	Y (Migeon and Dorkeld, 2006)	N						No
Tetranychus urticae Koch, 1836	two-spotted spider mite	Y (CPC, 2007)	Y (Migeon and Dorkeld, 2006; Bi *et al*, 2007; Zhang *et al*, 2008a)	Y (Migeon and Dorkeld, 2006; CPC, 2007; PPIN, 2009)	Y[v]	No	No	No	No	No	No
Trachelas pacificus Chamberlin and Ivie, 1935		Indirect (Reed and Newland, 2002)*(MAFB NZ, 2008)	N	N (PPIN, 2009)	N						No
Phytoplasma											
Grapevine flavescence doree phytoplasma		N (CPC, 2007)	Y (AQSIQ, 2007)	N (PPIN, 2009)	Y^						No
Viruses											
Apple fruit crinkle viroid		Y (Grove *et al*, 2003)	N	N (PPIN, 2009)	N^						No
Australian grapevine viroid		N (Frison and Ikin, 1991)	Y (Guo *et al*, 2007; Guo *et al*, 2007)	N (PPIN, 2009)	N^						No
Broad bean wilt virus		Y (CPC, 2007)	Y (UK, 2004a; Wu *et al*, 1999)	Y (PPIN, 2009)	Y^	N	N	N	N	N	No
Grapevine fanleaf virus		Y (CPC, 2007)	Y (UK, 2000a; Liu *et al*, 2004a)	Y (UK, 2000a)	Y^	N	N	N	N	N	No
Grapevine leafroll associated virus 1		Y	Y (Hong, 2005)	Y (Yamoah, 2007)	Y^	N	N	N	N	N	No

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Grapevine leafroll associated virus 2		Y	Y (Hong, 2005; Liu *et al*, 2006)	Y (Yamoah, 2007)	N^	N	N	N	N	N	No
Grapevine leafroll associated virus 3		Y	Y (Hong, 2005; Ribeiro *et al*, 2004)	Y (Yamoah, 2007)	Y^	N	N	N	N	N	No
Grapevine leafroll associated virus 4		Y	N	Y (Yamoah, 2007)	N^					N	No
Grapevine leafroll associated virus 5		Y	N	Y (Yamoah, 2007)	Y^						No
Grapevine leafroll associated virus 6		Y	N	N (Yamoah, 2007)	N^						No
Grapevine leafroll associated virus 7		Y	Y (Hong, 2005)	N (Yamoah, 2007)	N@						No
Grapevine leafroll associated virus 8		Y	N	N (Yamoah, 2007)	N^						No
Grapevine leafroll associated virus 9		Y	N	Y (Yamoah, 2007)	Y^						No
Grapevine leafroll associated virus 10		Y	N	N (Yamoah, 2007)	N^						No
Grapevine virus A (syn. Grapevine corky bark associated virus; Grapevine stempitting associated virus)		Y	Y (Ribeiro *et al*, 2004)	Y (Pearson *et al*, 2006; Pennycook, 1989)	Y^	N	N	N	N	N	No
Grapevine virus B		Y	Y (Ribeiro *et al*, 2004)	Y (Pearson *et al*, 2006; Pennycook, 1989)	Y^	N	N	N	N	N	No
Grapevine yellow speckle viroid 1		Y	Y (Li *et al*, 2007)	Y (Pennycook, 1989, PPIN 2009)	N^	N	N	N	N	N	No

Scientific name and Authority	Common name	Commodity association (see note 1)	Present in China (reference) (see note 2)	Present in NZ (reference) (see note 3)	Vect-or	In NZ but associat-ion with goods increases hazard	In NZ but geogra-phically bounded	In NZ but has different host associations or strains	No or little informat-ion on organism	Under official control or notifiable	Potent-ial hazard
Grapevine yellow speckle viroid 2		Y	Y (Li *et al*, 2007)	Y (Pennycook, 1989) Unconfirmed/Probably (Pearson *et al*, 2006)	N^	N	N	N	N	N	No

Note 1: The reference provided indicates a direct association with the table grape bunches (table grape commodity); N does not exclude associations with other parts of *Vitis vinifera* plants.
Note 2: The reference provided indicates that these organisms may be in China; however, there may not be any available record of these organisms being associated with *Vitis vinifera* in China.
Note 3: The references provided may indicate that the organism or disease is not in New Zealand, or may indicate that the organism or disease is absent from a list of organisms and diseases considered present in New Zealand.

***** Intercepted on grapes coming into New Zealand from other countries.
# Interceptions and a subsequent pest risk assessment indicated spiders as a problem hitchhiker species on grapes.
¢ Some doubt exists on the presence of this fungus on rachis. Since no conclusive scientific evidence was found it is considered not to be present on the pathway.
^ In relation to viruses this means a vector is known.
@ Assistant Professor Marc Fuchs (Cornell University) has stated: "To date, no insect vector is known to transmit GLRaV-7. However, based on the limited information available on the biology of this virus species, it is conceivable that whiteflies could act as vectors for GLRaV-7. Needless to say this is speculative. More work is needed to better characterise GLRaV-7 and its potential vector(s)." Pers. comm. 10/2/2009.
~ Based on the presence of grape-associated strains in New Zealand (PPIN), it is proposed that it is not considered a potential hazard and as such does not require further assessment.
[V] These organisms are capable of acting as a vector and are therefore discussed in Appendix 3.
$ The review of Wermelinger and others (2008) states *Vitis vinifera* as a host. None of the articles they refer to state *V. vinifera* as a host. Moreover, a literature search did not come up with any articles showing *V. vinifera* as a host. Therefore, the statement by Wermerlinger and others (2008) that *V. vinifera* is a host is considered an error.
+ The information provided by AQSIQ (2009) about the *Merhynchites* spp. present in China states the following: The adult bites the fruit to produce holes inside the fruit, the colour around the hole turning black brown. The fruit may fall down. The larva gnaws the seed in the fruit, thus reducing the size of the fruit and making it without edible value. The fruit damage by larva mainly falls at nigh." This indicates that damaged grapes become inedible and have clear symptoms, and will not be harvested. Therefore, this group is not considered a hazard.

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Appendix 3: Vector analysis

The following species are considered here because they are known vectors of various pathogens.

Aphis craccivora Koch, 1854 (Hemiptera: Aphididae)
Present in New Zealand: Yes (Teulon *et al*, 2004; PPIN, 2009)
Present in China: Yes (Li *et al*, 2005; Liu *et al*, 2005; CPC, 2007)
Associated with grape bunches: No (CPC, 2007)
Vector of: Alfalfa mosaic virus; Asparagus 1 virus; Bean common mosaic virus; Bean leaf roll virus; Bean yellow mosaic virus; Beet western yellows virus; Blackeye cowpea mosaic virus; Broad bean wilt virus; Broad bean wilt virus 2; Canavalia maritima mosaic virus; Chickpea distortion mosaic virus; Chilli veinal mottle virus; clover stunt virus; Clover yellows virus; Cowpea mild mottle virus; Cowpea stunt virus; Cucumber mosaic virus; Dasheen mosaic virus; Datura distortion mosaic virus; Desmodium mosaic virus; Elm mottle virus; Faba bean necrotic yellows virus; Groundnut eyespot virus; Groundnut rosette assistor virus; Hippeastrum mosaic virus; Johnsongrass mosaic virus; Lucerne Australian latent virus; Lucerne transient streak virus; Maize dwarf mosaic virus; Papaya ringspot virus; Pea leaf roll virus; Pea seed-borne mosaic virus; Peanut stunt virus; Plum pox virus; Red clover necrotic mosaic virus; Robinia mosaic virus; Soybean dwarf virus; Subterranean clover stunt virus; Sweet potato mild mottle virus; Tephrosia symptomless virus; Tobacco vein mottling virus; Soybean chlorotic mottle virus; Voandzeia necrotic mosaic virus; Watermelon mosaic virus-2; Zucchini yellow mosaic virus (Brunt *et al*, 2007; Dams and Antoniw, 2005; CPC, 2007)
Hazard identification conclusion: *Aphis craccivora* can vector many different viruses. Some of these viruses are present in China. There is no evidence that *A. craccivora* has a direct biological association with grape bunches and therefore it is not considered a hazard on this commodity. However, an interception record of *A. craccivora* on grapes from Italy at the New Zealand border in 2002 (viability not recorded; MAFBNZ, 2009) shows that this species may occur as an occasional hitchhiker on imported fresh table grapes.

Aphis fabae Scopoli, 1763 (Hemiptera: Aphididae)
Present in New Zealand: No (Teulon *et al*, 2004; PPIN, 2009)
Present in China: Yes (Liu *et al*, 2005; UK, 1963; CPC, 2007)
Associated with grape bunches: No (CPC, 2007; Ingels *et al*, 1998)
Vector of: Bean common mosaic virus; Bean yellow mosaic virus; Beet mosaic virus; Beet yellows virus; Broad bean wilt virus; Clover yellow vein virus; Cowpea mild mottle virus; Dahlia mosaic virus; Elderberry carlavirus; Iris fulva mosaic virus; Leek yellow stripe virus; Maize dwarf mosaic virus; Narcissus yellow stripe virus; Potato virus Y; Red clover necrotic mosaic virus; Shallot latent virus; Soybean mosaic virus; Tobacco etch virus; Watermelon mosaic virus (Dams and Antoniw, 2005; CPC, 2007; Brunt *et al*, 2007)
Hazard identification conclusion: *Aphis fabae* can vector many different viruses. Some of these viruses are present in China. There is no evidence that *A. fabae* has a

direct biological association with grape bunches and therefore it is not considered a hazard on this commodity.

Aphis gossypii Glover, 1877 (Hemiptera: Aphididae)
Present in New Zealand: Yes (Teulon *et al*, 2004; PPIN, 2009)
Present in China: Yes (Liu *et al*, 2005; CPC, 2007)
Associated with grape bunches: No (CPC, 2007)
Vector of: Alfalfa mosaic virus; Arracacha Y potyvirus; Bean common mosaic virus; Beet western yellows virus; Calotropis ringspot mosaic virus; Canavalia maritima mosaic virus; Carnation mottle virus; Cauliflower mosaic virus; Celery mosaic virus; Chickpea distortion mosaic virus; Chinese yam necrotic mosaic virus; Citrus enation - woody gall virus; Citrus tristeza virus; Citrus woody gall virus; Commelina mosaic virus; Cotton anthocyanosis virus; Cowpea (aphid-borne) mosaic virus; Cucumber mosaic virus; Dasheen mosaic virus; Datura distortion mosaic virus; Dioscorea trifida potyvirus; Garlic mosaic virus; Greengram mosaic virus; Hippeastrum mosaic potyvirus; Infectious chlorosis of banana; Iris mild mosaic virus; Johnsongrass mosaic virus; Leaf crinkle of sunflower; Lettuce mosaic virus; Lily symptomless virus; Muskmelon yellow stunt virus; Narcissus latent virus; Onion yellow dwarf virus; Papaya ringspot virus W (=Watermelon mosaic virus 1); Passiflora ringspot virus; Passionfruit Sri Lankan mottle virus; Passionfruit woodiness potyvirus; Pea enation mosaic virus; Peanut mottle virus; Pepper Indian mottle virus; Pepper veinal mottle virus; Potato leafroll virus; Potato virus Y; Solanum trovum mosaic virus; Strawberry mottle virus; Strawberry pseudo mild yellow edge virus; Subterranean clover stunt virus; Sugarcane mosaic virus; Sunflower yellow blotch virus; Sweet potato feathery mottle virus; Swordbean distortion mosaic virus; Tobacco ringspot virus; Trichosanthes mottle virus; Tulip breaking virus; Turnip mosaic virus; Vanilla necrosis virus; Watermelon mosaic virus 2; Yam mosaic virus; Yellow vein mosaic virus; Zucchini yellow mosaic virus (Dams and Antoniw, 2005; CPC, 2007; Brunt *et al*, 2007)
Hazard identification conclusion: *Aphis gossypii* can vector many different viruses. Some of these viruses are present in China. There is no evidence that *A. gossypii* has a direct biological association with grape bunches and therefore it is not considered a hazard on this commodity. However, an occasional indirect association as a hitchhiker is indicated by interception records of *A. gossypii* on fresh table grapes from the USA at the New Zealand border in 1988 (2 dead adults) and 1993 (one live adult) (MAFBNZ, 2009).

Arboridia apicalis (Nawa, 1913) (Hemiptera: Cicadellidae)
Present in New Zealand: No (Scott and Emberson, 1999; Spiller and Wise, 1982; PPIN, 2009)
Present in China: Yes (FAO, 2007; Ma *et al*, 2004)
Associated with grape bunches: No (USapple.org, 2003)
Vector of: Grapevine stunt virus (ICTVdb, 2004)
Hazard identification conclusion: *Arboridia apicalis* transmits Grapevine stunt virus in a persistent manner. This virus does not occur in China (ICTVdb, 2004). Moreover, there is no evidence that *A. apicalis* has a direct biological association with grape bunches and therefore it is not considered a hazard on this commodity.

Cryptoblabes gnidiella Millière 1867 (Lepidoptera: Pyralidae)
Present in New Zealand: No (Dugdale, 1988).
Present in China: No (CPC, 2007).
Associated with grape bunches: Yes (CPC, 2007).
Vector of: *Botrytis cinerea* (CPC, 2007).
Hazard identification conclusion: *Cryptoblabes gnidiella* transmits *Botrytis cinerea*. *B. cinerea* is already present and widespread in New Zealand and has been recorded from grapes (Landcare Research, 2009). Moreover, there is no evidence that *C. gnidiella* is present in China and therefore it is not considered a hazard on this commodity.

Drosophila melanogaster Meigen, 1830 (Diptera: Drosophilidae)
Present in New Zealand: Y (Macfarlane *et al*, 2000; PPIN, 2009)
Present in China: Y (Jiang *et al*, 1989)
Associated with grape bunches: Y (CPC, 2007)
Vector of: *Botrytis cinerea* (Louis *et al*, 1996), *Saccharomyces cerevisiae* (EOL, 2009)
Hazard identification conclusion: *D. melanogaster* is present in both China and New Zealand. *D. melanogaster* is known to transmit *Botrytis cinerea* and *Saccharomyces cererisiae*, both of which are already present in New Zealand. *D. melanogaster* is known as an effective vector for many microorganisms (CPC, 2007, EOL, 2009). However, this assessment did not find any evidence that it transmits viruses known to be present in China but not present in New Zealand and therefore it is not considered a hazard on this commodity.

Epiphyas postvittana Walker, 1863 (Lepidoptera: Tortricidae)
Present in New Zealand: Yes (Dugdale, 1988; Hoare, 2001; PPIN, 2009).
Present in China: No (CPC, 2007).
Associated with grape bunches: Yes (CPC, 2007).
Vector of: *Botrytis cinerea* (CPC, 2007).
Hazard identification conclusion: *Epiphyas postvittana* transmits *Botrytis cinerea*. *B. cinerea* is already present and widespread in New Zealand. Moreover, there is no evidence that *E. postvittana* is present in China and therefore it is not considered a hazard on this commodity.

Frankliniella occidentalis (Pergande, 1895) (Thysanoptera: Thripidae)
Present in New Zealand: Yes (Nakahara, 1997; PPIN, 2009; Scott and Emberson, 1999)
Present in China: Yes (Nakahara, 1997; Liang *et al*, 2007)
Associated with grape bunches: Yes (CPC, 2007)
Vector of: Chrysanthemum stem necrosis virus; Groundnut ringspot virus; Impatiens necrotic spot tospovirus; Pelargonium flower break virus; Tobacco streak virus; Tomato chlorotic spot virus; Tomato spotted wilt virus (Brunt *et al*, 2007, CPCI 2007; Pearson *et al*, 2006)
Hazard identification conclusion: *Frankliniella occidentalis* is present in China and New Zealand. *F. occidentalis* is capable of vectoring several viruses. Of the viruses known to be vectored by *F. occidentalis* only Tobacco streak virus and Tomato spotted wilt virus are present in China, but the same two viruses are also widespread

in New Zealand. These viruses are not considered hazards. Therefore, *F. occidentalis* is not considered a hazard on this commodity.

Homalodisca coagulata (Say, 1832) (Homoptera: Cicadellidae)
Present in New Zealand: No (PPIN, 2009; CPC, 2007)
Present in China: No (CPC, 2007)
Associated with grape bunches: Yes (CPC, 2007)
Vector of: *Xylella fastidiosa* (Pierce's disease) (CPC, 2007)
Hazard identification conclusion: *Homalodisca coagulata* transmits *Xylella fastidiosa* (Pierce's disease). There is no evidence that *H. coagulata* or *X. fastidiosa* are present in China, therefore *Homalodisca coagulata* is not considered a hazard on this commodity.

Hypera postica Germar, 1821 (Coleoptera: Curculionidae)
Present in New Zealand: No (PPIN, 2009; CPC, 2007)
Present in China: Yes (CPC, 2007; Bai *et al*, 1990)
Associated with grape bunches: No (CPC, 2007)
Vector of: Broad bean mottle bromovirus (CPC, 2007)
Hazard identification conclusion: *Hypera postica* transmits Broad bean mottle bromovirus. This virus does not infect *Vitis vinifera* and is not present in China. Moreover, *H. postica* has a preference for legumes (CPC, 2007) and there is no evidence that it has a direct biological association with grape bunches; therefore it is not considered a hazard on this commodity.

Leptoglossus gonagra (Fabricius, 1775) (Hemiptera: Coreidae)
Present in New Zealand: No (PPIN, 2009; CPC, 2007)
Present in China: Yes (CPC, 2007)
Associated with grape bunches: No (CPC, 2007)
Vector of: *Nematospora coryli* (Grillo and Alvarez, 1983)
Hazard identification conclusion: *Leptoglossus gonagra* transmits *Nematospora coryli*. *N. coryli* is present in China but does not infect *Vitis vinifera*. Moreover, there is no evidence that *Leptoglossus gonagra* has a direct biological association with grape bunches and therefore it is not considered a hazard on this commodity.

Parthenolecanium corni (Bouche, 1844) (Hemiptera: Coccidae)
Present in New Zealand: Yes (PPIN, 2009; CPC 2007)
Present in China: Yes (AQSIQ, 2007; Yang *et al*, 2005b; UK, 1999a)
Associated with grape bunches: No (AQSIQ, 2007; Yang *et al*, 2005b)
Vector of: Grapevine leafroll-associated virus-1; Grapevine leafroll-associated virus-3; Grapevine virus A (Sforza *et al*, 2003)
Hazard identification conclusion: *Parthenolecanium corni* transmits three different grapevine viruses. These viruses are present in China, but also widespread in New Zealand and therefore not classify as a hazard. There is no evidence that *P. corni* has a direct biological association with grape bunches and therefore it is not considered a hazard on this commodity.

Planococcus citri (Risso, 1813) (Hemiptera: Pseudococcidae)
Present in New Zealand: Yes (PPIN, 2009; CPC, 2007)
Present in China: Yes (CPC, 2007; UK, 1999b)

Associated with grape bunches: Yes (CPC, 2007)
Vector of: Banana streak virus; Cacao swollen shoot virus; Cucumber mosaic virus; Schefflera ringspot virus (Brunt *et al*, 2007; Dams and Antoniw, 2005; CPC, 2007)
Hazard identification conclusion: *Planococcus citri* transmits several different viruses. None of the viruses are associated with *Vitis vinifera* in China. Therefore *Planococcus citri* is not considered a hazard on this commodity.

Pseudococcus calceolariae (Maskell, 1879) (Hemiptera: Pseudococcidae)
Present in New Zealand: Yes (CPC, 2007; PPIN, 2009; Ben-Dov *et al*, 2006)
Present in China: Yes (CPC, 2007; Ben-Dov *et al*, 2006)
Associated with grape bunches: Yes (CPC, 2007)
Vector of: Grapevine leafroll-associated virus-3 (Petersen and Charles, 1997)
Hazard identification conclusion: *Pseudococcus calceolariae* transmits a virus that is present on *Vitis vinifera*. This virus is present in China as well as being widespread in New Zealand, and is therefore not considered to be a hazard. Since *P. calceolariae* is already present in New Zealand it is not considered a hazard.

Pseudococcus longispinus (Targioni-Tozzetti, 1867) (Hemiptera: Pseudoccidae)
Present in New Zealand: Yes (CPC, 2007; PPIN, 2009; Ben-Dov *et al*, 2006)
Present in China: Yes (CPC, 2007; Ben-Dov *et al*, 2006)
Associated with grape bunches: Yes (CPC, 2007)
Vector of: Grapevine leafroll-associated virus-3; Grapevine leafroll-associated virus-5; Grapevine virus A (Petersen and Charles, 1997; Golino *et al*, 2002; CPC, 2007)
Hazard identification conclusion: *Pseudococcus longispinus* transmits three different viruses that are present on *Vitis vinifera*. Two viruses are present in China as well as being widespread in New Zealand, and are therefore not considered to be a hazard. Grapevine leafroll-associated virus-5 is not known to be present in China, and therefore not considered a hazard. Since *P. longispinus* is already present in New Zealand it is not considered a hazard.

Pseudococcus viburni (Signoret, 1875) (Hemiptera: Pseudococcidae)
Present in New Zealand: Yes (PPIN, 2009; CPC, 2007)
Present in China: No (CPC, 2007)
Associated with grape bunches: Yes (CPC, 2007)
Vector of: Grapevine leafroll-associated virus-3; Grapevine virus A; Grapevine virus B (Charles *et al*, 2006)
Hazard identification conclusion: *Pseudococcus viburni* transmits three different viruses that are present on *Vitis vinifera*. These three viruses are present in China as well as being widespread in New Zealand, and are therefore not considered to be a hazard. Moreover, *Pseudococcus viburni* is not known to be present in China and therefore it is not considered a hazard on this commodity.

Thrips tabaci Lindeman, 1889 (Thysanoptera: Thripidae)
Present in New Zealand: Yes (CPC, 2007; PPIN, 2009; Scott and Emberson, 1999)
Present in China: Yes (CPC, 2007; AQSIQ, 2007)
Associated with grape bunches: No (CPC, 2007; AQSIQ, 2007)

Vector of: Iris yellow spot virus; Maize chlorotic mottle virus; Prunus necrotic ringspot virus; Sowbane mosaic virus; Tobacco streak virus; Tomato spotted wilt virus; Tobacco ringspot virus (Brunt *et al*, 2007)
Hazard identification conclusion: *Thrips tabaci* transmits a range of different viruses. *T. tabaci* does not transmit any viruses that are known to be present on *Vitis vinifera* in China but not in New Zealand. Moreover, *Thrips tabaci* has no known biological association with grape bunches and therefore it is not considered a hazard on this commodity.

Brevipalpus californicus (Banks, 1904) (Acarina: Tenuipalpidae)
Present in New Zealand: Yes (PPIN, 2009; CPC, 2007)
Present in China: Yes (CPC, 2007)
Associated with grape bunches: Yes (CPC, 2007)
Vector of: Citrus leprosis virus; Orchid fleck virus (CPC, 2007)
Hazard identification conclusion: *Brevipalpus californicus* transmits two different viruses. Neither of these viruses is known to affect *Vitis vinifera* therefore they are not considered a hazard. Since *Brevipalpus californicus* is already present in New Zealand it is not considered a hazard on this commodity.

Colomerus vitis (Pagenstecher, 1857) (Acari: Eriophyidae)
Present in New Zealand: Yes (PPIN, 2009; CPC, 2007).
Present in China: Yes (AQSIQ, 2007; Papademetriou and Dent, 2001).
Associated with grape bunches: No (AQSIQ, 2007; CPC, 2007).
Vector of: grapevine berry inner necrosis virus (Kunugi *et al*, 2000).
Hazard identification conclusion: *Colomerus vitis* transmits Grapevine berry inner necrosis virus. There is no evidence that the virus is present in China. Moreover, *Colomerus vitis* has no known biological association with grape bunches and therefore it is not considered a hazard on this commodity.

Tetranychus urticae Koch, 1836 (Acari: Tetranychidae)
Present in New Zealand: Yes (Migeon and Dorkeld, 2006; CPC, 2007; PPIN, 2009).
Present in China: Yes (Migeon and Dorkeld, 2006; Bi *et al*, 2007; Zhang *et al*, 2008a).
Associated with grape bunches: Yes (CPC, 2007).
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, or other, plant viruses (CPC, 2007; Brunt *et al*, 2007). Therefore, *T. urticae* is considered not to be a vector of these viruses.
Hazard identification conclusion: *T. urticae* is present in China, but also widespread in New Zealand. Therefore, *Tetranychus urticae* is not considered a potential hazard in this analysis.

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Appendix 4: 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 (for example 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 for example 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” (for example, adventive, exotic, alien, introduced, naturalised, 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 Pub. 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 Pub. 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).

Quancargo 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 (for example 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.