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Department of Agriculture, Fisheries and Forestry
Biosecurity

Draft import risk analysis report for fresh ginger from Fiji

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Cover image: *Fijian ginger rhizomes after harvest.* Photographed by DAFF Biosecurity officer, September 2007.

Submissions

This draft import risk analysis (IRA) report has been issued to give all interested parties an opportunity to comment and draw attention to any scientific, technical, or other gaps in the data, misinterpretations and errors. Any comments should be submitted to DAFF Biosecurity within the comment period stated in the related Biosecurity Advice on the Department of Agriculture, Fisheries and Forestry website. The draft IRA report will then be revised as necessary to take account of the comments received and a provisional final IRA report will be released at a later date.

Comments on the draft IRA report should be submitted to:

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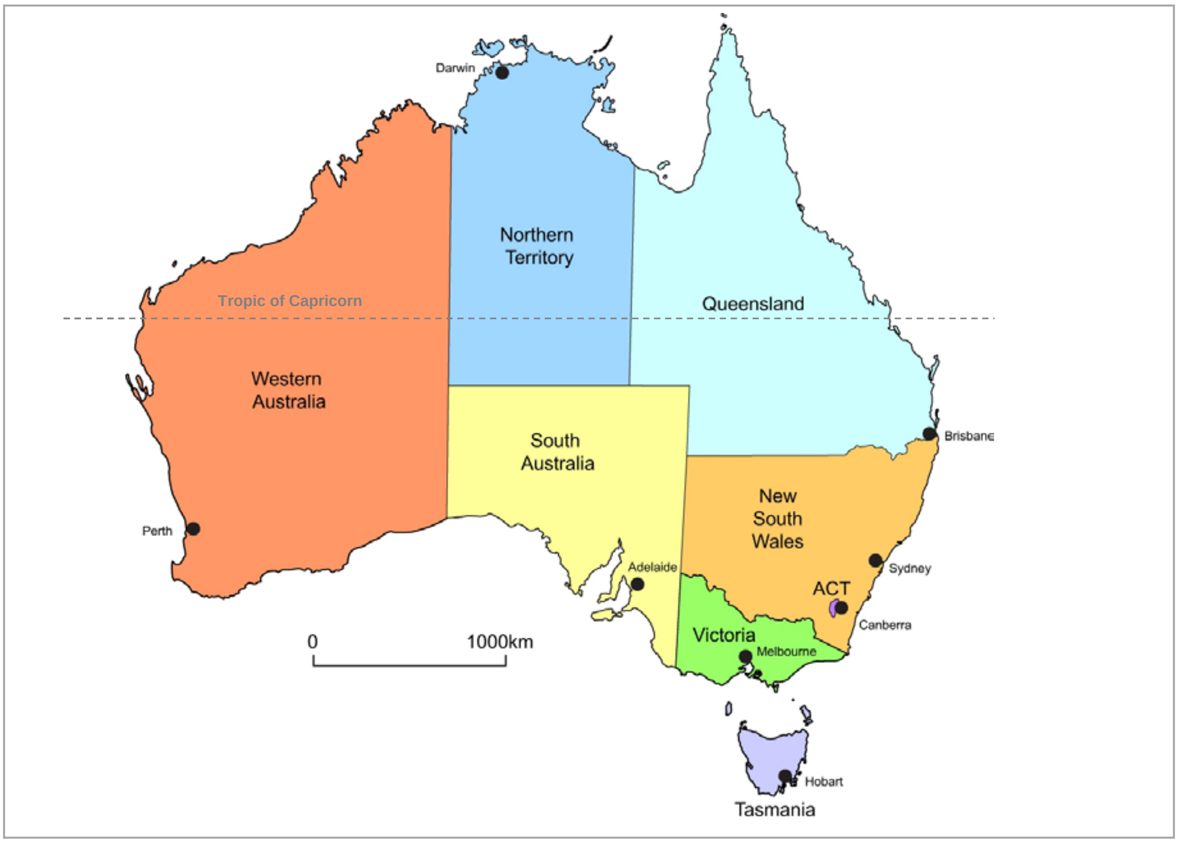

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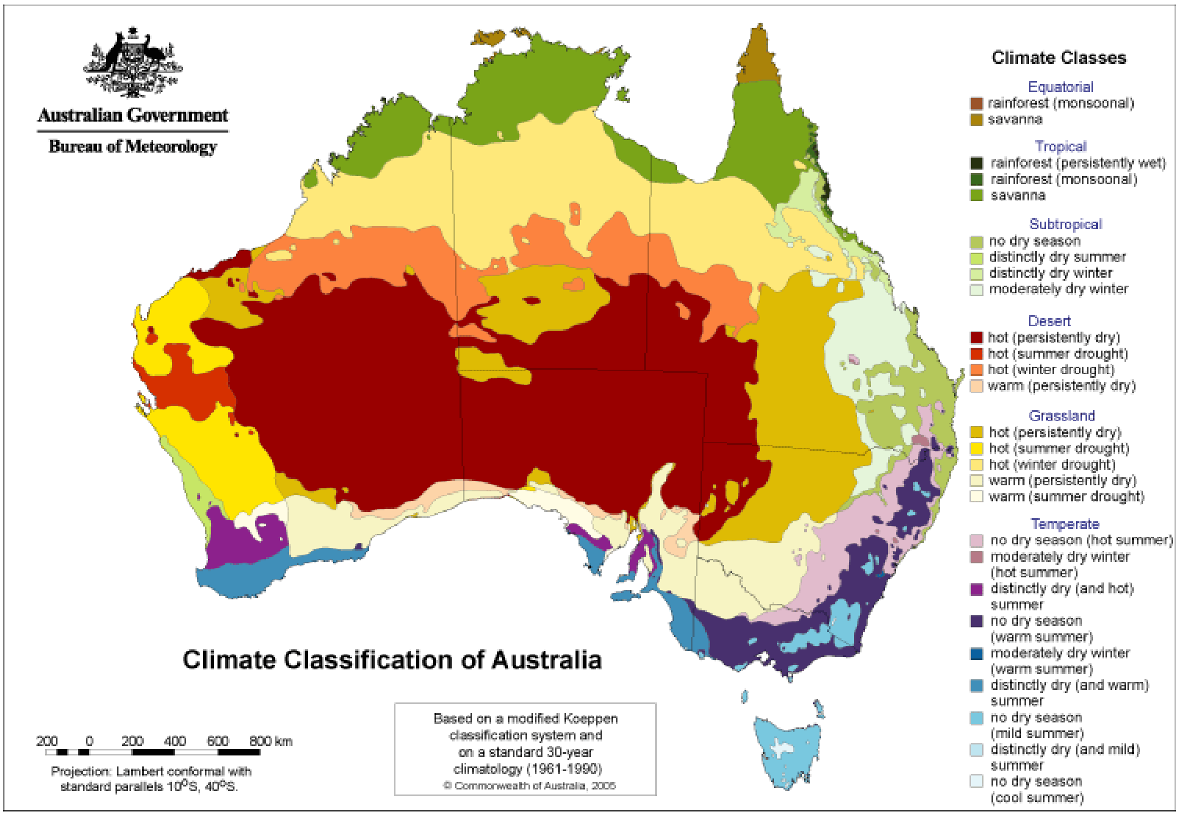

Acronyms and abbreviations

Term or abbreviation	Definition
ALOP	Appropriate level of protection
APPD	Australian Plant Pest Database (Plant Health Australia)
CABI	Centre for Agricultural Bioscience International, Wallingford, UK
CMI	Commonwealth Mycological Institute
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
FAO	Food and Agriculture Organization of the United Nations
IPC	International Phytosanitary Certificate
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IRA	Import Risk Analysis
ISPM	International Standard for Phytosanitary Measures
NPPO	National Plant Protection Organization
NSW	New South Wales
NT	Northern Territory
Qld	Queensland
SA	South Australia
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995)
Tas.	Tasmania
Vic.	Victoria
WA	Western Australia
WTO	World Trade Organisation

Abbreviations of units

Term or abbreviation	Definition
ºC	degree Celsius
Gy	gray
kg	kilogram
km	kilometre
Krad	kilorad
m	metre
mm	millimetre

Summary

The Department of Agriculture, Fisheries and Forestry Biosecurity (DAFF Biosecurity) is assessing the quarantine risks associated with the importation of fresh ginger (*Zingiber officinale*) rhizomes from Fiji. This draft report proposes phytosanitary measures for fresh ginger from Fiji.

The yam scale, *Aspidiella hartii*, has been identified as a quarantine pest requiring measures to manage the risks to a very low level in order to achieve Australia's appropriate level of protection. Ginger rhizomes must be subject to phytosanitary inspection to ensure that consignments are free of scales or any other regulated articles. Where quarantine pests or other regulated articles are detected, consignments will be subject to appropriate remedial action.

Australia has a system of operational procedures in place to ensure quarantine standards are met. These include: provisions for traceability to enable tracing of consignments to critical points of the pathway; registration of export farms and packing houses; packaging and labelling requirements to ensure material is not contaminated by quarantine pests or other regulated articles; and pre-export phytosanitary certification to document the above provisions.

This draft report provides risk assessments for pests of ginger and proposed phytosanitary procedures to allow interested parties to provide comments and submissions to DAFF Biosecurity within the consultation period of 60 days.

1 Introduction

1.1 Australia's biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests[1] entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as those agricultural industries that are relatively free from serious pests.

The import risk analysis (IRA) process is an important part of Australia's biosecurity policies. It enables the Australian Government to formally consider the risks that could be associated with proposals to import new products into Australia. If the risks are found to exceed Australia's appropriate level of protection (ALOP), risk management measures are proposed to reduce the risks to an acceptable level. But, if it is not possible to reduce the risks to an acceptable level, then no trade will be allowed.

Successive Australian Governments have maintained a conservative, but not a zero risk, approach to the management of biosecurity risks. This approach is expressed in terms of Australia's ALOP, which reflects community expectations through government policy and is currently described as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's IRAs are undertaken by the Department of Agriculture, Fisheries and Forestry Biosecurity, hereafter referred to as DAFF Biosecurity, using teams of technical and scientific experts in relevant fields, and involves consultation with stakeholders at various stages during the process. DAFF Biosecurity provides recommendations for animal and plant quarantine policy to Australia's Director of Animal and Plant Quarantine (the Secretary of the Australian Government Department of Agriculture, Fisheries and Forestry). The Director, or delegate, is responsible for determining whether or not an importation can be permitted under the *Quarantine Act 1908*, and if so, under what conditions.

More information about Australia's biosecurity framework is provided in Appendix C of this report and in the *Import Risk Analysis Handbook 2007 (update 2011)* located on the DAFF website http://daff.gov.au.

1.2 This import risk analysis

1.2.1 Background

The Fiji Agriculture Quarantine and Inspection Division (now known as the Biosecurity Authority of Fiji) formally requested market access for fresh ginger (*Zingiber officinale*) in a submission received in November 2003. This submission included information on the pests associated with ginger crops in Fiji. Further information was provided on the ginger production system in 2004 and 2007, outlining the land preparation, pest management, harvesting and postharvest handling.

[1] A pest is any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2010).

On 13 August 2010, DAFF Biosecurity advised stakeholders that this market access request would be progressed as a standard IRA, using the process described in the *Import Risk Analysis Handbook 2007*.

1.2.2 Scope

This IRA report assesses the biosecurity risks associated with the importation of fresh ginger from Fiji for human consumption. This includes both mature and immature ginger. Details of the production processes for the ginger are set out in Section 3.

This report does not consider the risks associated with the importation of seed ginger specifically for propagation purposes on a commercial scale. The intentional importation of fresh ginger for the purposes of propagation (for example, by farmers) under an import permit for human consumption is a breach of import permit conditions, and liable to prosecution under the *Quarantine Act 1908*. The report does, however, take into account the possibility that consumers could potentially plant rhizomes purchased from retail markets, as this pathway cannot be effectively regulated. It is expected that volumes of ginger diverted to growing purposes by consumers would be small.

Regional pest freedoms are not considered in the pest categorisation process where there are no specific management measures applied to interstate movement of ginger that exceed the standard requirements for clearance of imported fresh produce (i.e. inspection on arrival). Consistent with the obligations under the SPS Agreement, Australia must apply phytosanitary measures without discrimination between domestic and imported consignments.

1.2.3 Existing policy

Australia does not currently permit the importation of fresh ginger rhizomes for human consumption from any country.

Fresh ginger may only be imported into Australia for processing in a Quarantine Approved Premises. Processing involves the commercial drying, crystallisation, pickling or preservation of the ginger into a processed food form. Imports under this category may be permitted from all countries, but the method of processing must be approved by DAFF Biosecurity, and carried out in an approved facility where all waste is treated by appropriate methods to mitigate any quarantine concerns.

The importation of dried ginger is permitted from all countries. Dried ginger rhizomes must have a moisture content of less than 15 percent.

The import conditions for processed ginger products can be viewed on the DAFF Biosecurity import conditions database (ICON) at http://www.aqis.gov.au/icon.

1.2.4 Contaminating pests

In addition to the pests of fresh ginger from Fiji that are identified in this IRA, there are other organisms that may arrive with the ginger rhizomes. These organisms could include pests of other crops or predators and parasitoids of other arthropods. DAFF Biosecurity considers these organisms to be contaminating pests that could pose sanitary and phytosanitary risks. These risks are addressed by existing operational procedures. Further information on the management of contaminant pests, particularly ants, is covered in Section 5.2.

1.2.5 Consultation

DAFF Biosecurity received a report from the Australian Ginger Industry Association outlining their concerns following the announcement of the commencement of the IRA process in August 2010.

A draft pest categorisation table was distributed to the relevant state departments for comment to identify any concerns during preparation of the report. Submissions were received from Queensland, South Australia, Victoria and Western Australia.

In September 2011 DAFF Biosecurity met with the Australian Ginger Industry Association in Nambour, Queensland to discuss the IRA process and the pests of quarantine concern.

1.2.6 Next steps

This draft IRA report gives stakeholders the opportunity to comment and draw attention to any scientific, technical, or other gaps in the data, misinterpretations and errors.

DAFF Biosecurity will consider submissions received on the draft IRA report and may consult informally with stakeholders. DAFF Biosecurity will revise the draft IRA report as appropriate and then prepare a provisional final IRA report, taking into account stakeholder comments.

State and territory governments will be consulted on the proposed outcomes of the IRA.

The report will be distributed to the proposer and registered stakeholders and the documents will be placed on the public file and the DAFF website.

The regulated timeframe for an IRA ends when a provisional final IRA report is issued.

Stakeholders who believe there was a significant deviation from the IRA process set out in the *Import Risk Analysis Handbook 2007 (update 2011)* that adversely affected their interests may appeal to the Import Risk Analysis Appeals Panel (IRAAP). Appeals must be lodged within 30 days of the publication of the provisional final IRA report.

The appeals process is independent of DAFF Biosecurity. It is a non-judicial review that is not regulated under the Quarantine Regulations 2000 made under the *Quarantine Act 1908*.

Further details of the appeal process may be found at Annex 6 of the IRA Handbook.

At the conclusion of the appeal process and after any issues arising from the IRAAP process have been addressed, the First Assistant Secretary of DAFF Biosecurity will provide the final IRA report and a recommendation for a policy determination to the Director of Animal and Plant Quarantine.

The Director of Animal and Plant Quarantine will then make a determination. The determination provides a policy framework for decisions on whether or not to grant an import permit and any conditions that may be attached to a permit.

A policy determination represents the completion of the IRA process.

The Director of Animal and Plant Quarantine notifies DAFF Biosecurity of the policy determination. The proposer, registered stakeholders and the WTO Secretariat are also notified of the determination. The determination will also be placed on the public file and on the DAFF website.

2 Method for pest risk analysis

This section sets out the method used for the pest risk analysis (PRA) in this report. DAFF Biosecurity has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2011a) and ISPM 11: *Pest Risk Analysis for Quarantine Pests, including analysis of environmental risks and living modified organisms* (FAO 2011b).

A PRA is 'the process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it' (FAO 2010). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2010).

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

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

Restricted risk is estimated with phytosanitary measure(s) applied. A phytosanitary measure is 'any legislation, regulation or official procedure having the purpose to prevent the introduction and spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO 2010).

A glossary of the terms used is provided at the back of this report.

PRAs are conducted in three consecutive stages: initiation, pest risk assessment and pest risk management.

2.1 Stage 1: Initiation

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

The pests assessed for their potential to be on the exported commodity (produced using commercial production and packing procedures) are listed in column 1 of Appendix A. Appendix A does not present a comprehensive list of all the pests associated with the entire plant, but concentrates on the pests that could be on the assessed commodity. Pests that are determined to not be associated with the commodity are not considered further in the PRA. Contaminating pests that have no specific relation to the commodity or the export pathway have not been listed and would be addressed by Australia's current approach to contaminating pests.

The identity of the pests is given in Appendix A. The species name is used in most instances but a lower taxonomic level is used where appropriate. Synonyms are provided where the current scientific name differs from that provided by the exporting countries NPPO or where the cited literature uses a different scientific name.

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

2.2 Stage 2: Pest risk assessment

A pest risk assessment (for quarantine pests) is: 'the evaluation of the probability of the introduction and spread of a pest and of the likelihood of associated potential economic consequences' (FAO 2010).

In this PRA, pest risk assessment was divided into the following interrelated processes:

2.2.1 Pest categorisation

Pest categorisation identifies which of the pests with the potential to be on the commodity are quarantine pests for Australia and require pest risk assessment. A 'quarantine pest' is a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled, as defined in ISPM 5: *Glossary of phytosanitary terms* (FAO 2010).

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

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

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

2.2.2 Assessment of the probability of entry, establishment and spread

Details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11 (FAO 2011b). A summary of this process is given below, followed by a description of the qualitative methodology used in this IRA.

Probability of entry

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

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

For the purpose of considering the probability of entry, DAFF Biosecurity divides this step of this stage of the PRA into two components:

- **Probability of importation**: the probability that a pest will arrive in Australia when a given commodity is imported
- **Probability of distribution**: the probability that the pest will be distributed, as a result of the processing, sale or disposal of the commodity, in the PRA area and subsequently transfer to a susceptible part of a host.

Factors considered in the probability of importation include:

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

Factors considered in the probability of distribution include:

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

Probability of establishment

Establishment is defined as the ‘perpetuation for the foreseeable future, of a pest within an area after entry’ (FAO 2010). In order to estimate the probability of establishment of a pest, reliable biological information (lifecycle, host range, epidemiology, survival, etc.) is obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas where it currently occurs and expert judgement used to assess the probability of establishment.

Factors considered in the probability of establishment in the PRA area include:

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

Probability of spread

Spread is defined as ‘the expansion of the geographical distribution of a pest within an area’ (FAO 2010). The probability of spread considers the factors relevant to the movement of the pest, after establishment on a host plant or plants, to other susceptible host plants of the same or different species in other areas. In order to estimate the probability of spread of the pest, reliable biological information is obtained from areas where the pest currently occurs. The situation in the PRA area is then carefully compared with that in the areas where the pest currently occurs and expert judgement used to assess the probability of spread.

Factors considered in the probability of spread include:

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

Assigning qualitative likelihoods for the probability of entry, establishment and spread

In its qualitative PRAs, DAFF Biosecurity uses the term ‘likelihood’ for the descriptors it uses for its estimates of probability of entry, establishment and spread. Qualitative likelihoods are assigned to each step of entry, establishment and spread. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible (Table 2.1). Descriptive definitions for these descriptors and their indicative probability ranges are given in Table 2.1. The indicative probability ranges are only provided to illustrate the boundaries of the descriptors. These indicative probability ranges are not used beyond this purpose in qualitative PRAs. The standardised likelihood descriptors and the associated indicative probability ranges provide guidance to the risk analyst and promote consistency between different risk analyses.

Table 2.1 Nomenclature for qualitative likelihoods

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

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

For example, if the probability of importation is assigned a likelihood of 'low' and the probability of distribution is assigned a likelihood of 'moderate', then they are combined to give a likelihood of 'low' for the probability of entry. The likelihood for the probability of entry is then combined with the likelihood assigned to the probability of establishment (e.g. 'high') to give a likelihood for the probability of entry and establishment of 'low'. The likelihood for the probability of entry and establishment is then combined with the likelihood assigned to the probability of spread (e.g. 'very low') to give the overall likelihood for the probability of entry, establishment and spread of 'very low'.

Table 2.2 Matrix of rules for combining qualitative likelihoods

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

Time and volume of trade

One factor affecting the likelihood of entry is the volume and duration of trade. If all other conditions remain the same, the overall likelihood of entry will increase as time passes and the overall volume of trade increases.

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

These considerations have been taken into account when setting up the matrix. Therefore any policy based on this analysis does not simply apply to one year of trade. Policy decisions that are based on DAFF Biosecurity's method that uses the estimated volume of one year's trade are consistent with Australia's policy on appropriate level of protection and meet the Australian Government's requirement for ongoing quarantine protection. Of course, if there are substantial changes in the volume and nature of the trade in specific commodities then DAFF Biosecurity has an obligation to review the risk analysis and, if necessary, provide updated policy advice.

In assessing the volume of trade in this PRA, DAFF Biosecurity assumed that a substantial volume of trade will occur.

2.2.3 Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the likely consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing potential consequences are given in Article 5.3 of the SPS Agreement (WTO 1995), ISPM 5 (FAO 2010) and ISPM 11 (FAO 2011b).

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

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

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

- eradication, control, etc
- domestic trade
- international trade
- environment.

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

- **Local**: an aggregate of households or enterprises (a rural community, a town or a local government area).
- **District**: a geographically or geopolitically associated collection of aggregates (generally a recognised section of a state or territory, such as 'Far North Queensland').
- **Regional**: a geographically or geopolitically associated collection of districts in a geographic area (generally a state or territory, although there may be exceptions with larger states such as Western Australia).
- **National**: Australia wide (Australian mainland states and territories and Tasmania).

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

- **Indiscernible**: pest impact unlikely to be noticeable.

- **Minor significance**: expected to lead to a minor increase in mortality/morbidity of hosts or a minor decrease in production but not expected to threaten the economic viability of production. Expected to decrease the value of non-commercial criteria but not threaten the criterion's intrinsic value. Effects would generally be reversible.
- **Significant**: expected to threaten the economic viability of production through a moderate increase in mortality/morbidity of hosts, or a moderate decrease in production. Expected to significantly diminish or threaten the intrinsic value of non-commercial criteria. Effects may not be reversible.
- **Major significance**: expected to threaten the economic viability through a large increase in mortality/morbidity of hosts, or a large decrease in production. Expected to severely or irreversibly damage the intrinsic 'value' of non-commercial criteria.

The estimates of the magnitude of the potential consequences over the four geographic levels were translated into a qualitative impact score (A–G)[2] using Table 2.3[3]. For example, a consequence with a magnitude of 'significant' at the 'district' level will have a consequence impact score of D.

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

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

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

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

[3] The decision rules for determining the consequence impact score are presented in a simpler form in Table 2.3 from earlier IRAs, to make the table easier to use. The outcome of the decision rules is the same as the previous table and makes no difference to the final impact score.

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

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

2.2.4 Estimation of the unrestricted risk

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

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

Table 2.5 Risk estimation matrix

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

2.2.5 Australia's appropriate level of protection (ALOP)

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

Australia expresses its ALOP in qualitative terms. Australia's ALOP, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 2.5 marked 'very low risk' represents Australia's ALOP.

2.3 Stage 3: Pest risk management

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

The conclusions from pest risk assessment are used to decide whether risk management is required and if so, the appropriate measures to be used. Where the unrestricted risk estimate exceeds Australia's ALOP, risk management measures are required to reduce this risk to a very low level. The guiding principle for risk management is to manage risk to achieve Australia's ALOP. The effectiveness of any proposed phytosanitary measure (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure it reduces the restricted risk for the relevant pest or pests to meet Australia's ALOP.

ISPM 11 (FAO 2011b) provides details on the identification and selection of appropriate risk management options and notes that the choice of measures should be based on their effectiveness in reducing the probability of entry of the pest.

Examples given of measures commonly applied to traded commodities include:

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

Risk management measures are identified for each quarantine pest where the risk exceeds Australia's ALOP. These are presented in the 'Pest Risk Management' section of this report.

3 Fiji's commercial production practices for ginger

3.1 Assumptions used in estimating unrestricted risk

The following information on the existing commercial production practices in Fiji has been taken into consideration when estimating the unrestricted risk of pests likely to be associated with ginger produced in Fiji.

DAFF Biosecurity officers travelled to Fiji in September 2007 to observe the commercial production practices for ginger, examining the cultivation and harvesting methods, proposed pest control, and packing and transport protocols to produce and export ginger to Australia. This information forms the basis for estimating unrestricted risk in this Import Risk Analysis.

3.2 Ginger production

Ginger (*Zingiber officinale*) was introduced to Fiji in the late 1800s and cultivation was expanded into commercial production for export in the 1950s (Bridge 1988). Fiji has an ideal climate for growing ginger, with rainfall exceeding 3000 mm annually, accompanied by a prolonged hot season (Buresova and McGregor 1990).

The major ginger production area in Fiji is the Suva peninsula on the island of Viti Levu, particularly the Tamavua and Colo-i-Suva districts. Ginger production has also spread to the Sawani, Nabukaluka and Viria districts of Viti Levu. The area under cultivation is around 1000 hectares (Ravindran and Nirmal Babu 2004). There are two main types of ginger farms in Fiji: the small subsistence holdings like those of the Waicoba village in Navosa and the highlands of the Naitasiri province (Figure 3.1); and the commercial farms on the flat lands of the Navua district (Figure 3.2). In the highlands, the steep slopes provide well drained soils that are favourable for ginger production. However, the land relief and the small size of the holdings for the subsistence farmers make it uneconomical to employ mechanised assistance (Buresova and McGregor 1990).

Figure 3.1: Ginger farm in the highlands of Naitasiri

Figure 3.2: Commercial ginger production in Navua

Fiji currently exports fresh ginger to a number of countries including New Zealand, Canada and the United States for direct retail in supermarkets. Exports of fresh ginger from Fiji to the United States have declined after China was granted access to the US market, resulting in a significant reduction in ginger prices.

The importation of fresh ginger for further processing is currently permitted into Australia, subject to specific import conditions. The import requirements stipulate that the imported fresh mature ginger is to be processed commercially in a Quarantine Approved Premises by drying, crystallisation, pickling, or preservation of the ginger in brine. Fiji also exports processed ginger (preserved in sugar or brine, powdered ginger etc.) to Australia.

3.2.1 Cultivation practices

Ginger is an annual crop that is planted in the spring, and usually grown in rotation with cassava and taro (Buresova and McGregor 1990). Both cassava and taro are poor hosts of parasitic nematodes such as *Radopholus similis, Rotylenchulus reniformis* and *Meloidogyne* spp. (ACIAR 2010), so this practice helps suppress pest nematode populations. In addition to the crop rotation, a fallow period of about six months is usually included in the program. Ginger production is very labour intensive, with much of the land preparation and harvesting done by hand (Buresova and McGregor 1990). The ginger planting materials (or seed ginger) are usually selected and sourced on-farm from the previous crop, particularly in the highlands. Sourcing planting material from previous crops lessens the risk of pests and diseases being introduced from infected farms to new areas. The rhizomes are cut or broken into seed pieces, each around 60-70 g, with at least two eyes (Figure 3.3).

The ginger seed material may be dipped in hot water (51 °C) for ten minutes to kill any nematodes that may be carried on the seed material. The seed material is packed in onion bags to facilitate heat penetration and effective treatment. However, since the cessation of the government assistance that supplied gas for the hot water treatment, and the apparent absence of diseases affecting the planting material, some farmers have bypassed this process.

The seed pieces are left to dry for a few days before planting, further reducing the risk of introducing nematodes to the soil. Shrivelled seed material is discarded. Seed pieces may be dipped in fungicide (5 g/L Sundomil) for five minutes before they are taken for planting. Ideally, the planting should take place between August and September before the onset of the wet season. The ginger is planted in furrows around 90 cm apart and 10 cm deep.

Figure 3.3: Seed ginger material ready for planting

3.2.2 Harvesting and post harvest handling

The flat land commercial farmers harvest their ginger early (as immature or baby ginger) for processing into products such as ginger in brine. This minimises losses due to rotting, because the soils can become waterlogged in the lowland production areas. Immature ginger is harvested within 6 to 6.5 months. Mature ginger from the highlands is harvested within 10 to 12 months (Buresova and McGregor 1990). The ginger rhizomes are carefully lifted out of the soil by hand using digging forks, minimising damage and breakage. The ginger is transported from the field to the packing house in wooden crates.

3.2.3 Packing house

At the packing house, the ginger is weighed and quality assessed prior to being stacked on wire mesh for washing. The ginger rhizomes are washed individually with water using a high pressure hose to remove soil and external contaminants (Figure 3.4). They are then transferred on the wire mesh to a drying area where the rhizomes are left to dry for around 14 days (Figure 3.5). The roots are removed before the rhizomes are graded and inspected, and any pieces unsuitable for export are discarded. The ginger is packed into boxes (Figure 3.6) and stored in refrigerated shipping containers at about 10 °C.

Figure 3.4: Washing of ginger rhizomes

Figure 3.5: Ginger drying on wire mesh after washing

Figure 3.6: Packed ginger ready for export

3.2.4 Export procedures

Fresh mature ginger, produced and prepared as described above, is currently exported to New Zealand and United States without additional treatments.

3.3 Export capability

Southern Australia potentially offers a sizeable market for Fiji ginger (McGregor 2003). In Australia there is an estimated market for around 300 to 400 tonnes of ginger sourced from Pacific Island countries (McGregor 2007).

3.3.1 Production statistics

Ginger production in Fiji has fluctuated over time, but in recent years has been affected by the loss of export markets as a result of increased international competition (McGregor 2003), declining profits for growers (Singh 2010) and diseases caused by soil-borne pathogens (Raicola 2010). Available data on production volume does not reveal differences between immature ginger harvested for processing and mature ginger. Figures from the Agriculture Ministry published in the *Fiji Times* (13 August 2008) indicate that production of mature ginger increased by 31.9 percent between 2006 and 2007, with a corresponding rise in exports of 2.2 percent. However, this was followed by a big decline in production in 2008 (FAO 2011c). Table 3.1 shows production data for the last six years for which data is available.

Table 3.1: Ginger production in Fiji (FAO 2011c)

Year	2004	2005	2006	2007	2008	2009
Tonnes (t)	3770	3652	3209	3111	2448	3041

3.3.2 Export statistics

Fiji exports fresh ginger to the United States and New Zealand (McGregor 2007). Export figures for the last five years for which data is available are shown in Table 3.2. The USA imported 17 475 kg of fresh ginger from Fiji in 2007, and a further 103 357 kg of preserved ginger and 701.4 kg of ground ginger (Morita 2008).

Table 3.2: Ginger exports from Fiji (FAO 2011c)

Year	Tonnes (t)	Value ($Int)	Unit value ($/tonne)
2004	1414	3 980 000	2815
2005	1395	3 898 000	2794
2006	1187	3 283 000	2766
2007	1263	3 474 000	2751
2008	1395	3 671 000	2632

4 Pest risk assessments for quarantine pests

Quarantine pests associated with the fresh ginger from Fiji are identified in Appendix A. This chapter assesses the probability of the entry, establishment and spread of these pests and their likely potential economic, including environmental, consequences.

Pest categorisation identified eight quarantine pests associated with fresh ginger from Fiji. Table 4.1 identifies these quarantine pests and full details of the pest categorisation are provided in Appendix A. Pests are listed according to their taxonomic classification, consistent with Appendix A.

Table 4.1 Quarantine pests for fresh ginger from Fiji

Pest	Common name
Arthropods	
Elytroteinus subtruncatus	Fiji ginger weevil
Aspidiella hartii	Yam scale
Nematodes	
Discocriconemella discolabia	Ring nematodes
Mesocriconema denoudeni	
Helicotylenchus egyptiensis	Spiral nematodes
Helicotylenchus indicus	
Helicotylenchus mucronatus	
Sphaeronema sp.	Cystoid nematode

The estimated likelihoods and consequences of entry, establishment and spread for quarantine pests are presented in this section. The results of these estimates are summarised in Table 4.2, together with the overall unrestricted risk estimates. The rationale for each value of the pest risk assessment, summarised in this table, is described in the relevant sections below.

4.1 Fiji ginger weevil

Elytroteinus subtruncatus

Very little is known of the developmental biology of *Elytroteinus subtruncatus* because it is difficult to rear under laboratory conditions (Mau and Martin Kessing 1992a). Adult weevils are dark brown to black, and 6–8 mm in length (Mau and Martin Kessing 1992a). The adult female lays a single egg in the corms, tubers, fruits or soft stems of a range of plants. The larvae are legless, and creamy-white in colour with a distinct brown head. They are about 12 mm long when full size (Miller 1923). The larva bores through the plant tissues, completing its development inside the host. Detailed information on the life history of *Elytroteinus subtruncatus* is lacking, but other species in the subfamily Cryptorhynchinae take from five to eight weeks to develop from egg to adult (Woodruff and Fasulo 2009).

Elytroteinus subtruncatus is associated with a diverse range of plant hosts, including ginger rhizomes, taro (*Colocasia esculenta*) corms, avocado (*Persea americana*) seeds, daylily (*Hemerocallis* spp.) stems, kava (*Piper methysticum*) stems, cycad (*Cycas* spp.) trunks, ti (*Cordyline fruticosa*) cuttings, lemon (*Citrus limon*) fruit, dwarf mondo (*Ophiopogon japonicus*) roots, *Marrattia* fern trunks and dead sugarcane (*Saccharum* spp.) (Follett *et al*. 2007; Mau and Martin Kessing 1992a).

On kava, the adult female oviposits into the stem after boring a hole. The entire development of the weevil takes place inside the stem, with the larva tunnelling through it, filling the tunnels with frass, and causing stem dieback, leaf wilt, and rotting. Damage can be recognised by stem holes, which are filled with black powdery matter and frass (Fakalata 1981). On begonias, larvae bore into the main stems, usually near the base (Simmonds 1928). In lemons, female weevils puncture the fruit stalks near the base and lay their eggs there. Upon hatching, the larvae attack the fruit at the base of the stalk, and work their way through the peel and tissue lying immediately underneath. Pupation takes place in the fruit, although the fruit may decay before the adult has developed (Miller 1923).

Elytroteinus subtruncatus is endemic to a small number of countries in the South Pacific. It is also present in Hawaii and may have been introduced there. It first came to attention as a pest in the 1910s and 1920s (Miller 1923; Simmonds 1928). Recent references are scarce, suggesting that it is not a major pest. However, the weevil has been reported as a serious pest in Tonga, where it was recorded attacking stems of kava (Fakalata 1981).

In the United States of America (USA), the Animal and Plant Health Inspection Service (APHIS) considers *Elytroteinus subtruncatus* to be a high-risk pest requiring mitigation for sweet potatoes exported from Hawaii to the mainland. This is the result of five weevil interceptions in 1995 and 1997 (nine sweet potato roots containing a total of eight larvae and two pupae) found in passenger baggage at Keahole International Airport, Hawaii (Follett *et al*. 2007).

4.1.1 Probability of entry

Probability of importation

The likelihood that *Elytroteinus subtruncatus* will arrive in Australia with the importation of fresh ginger from Fiji is: **HIGH**.

- Weevil larvae burrow into the stems and rhizomes of ginger (Stout 1982) where they complete development. Pupation occurs within the feeding site (Mau and Martin Kessing 1992a).
- Feeding gives rise to wilting, loss of vigour, and in severe infestations the affected plants die (Mau and Martin Kessing 1992a).
- When disturbed, adult weevils in the subfamily Cryptorhynchinae typically feign death and drop to the ground (Lyal 1993). Such behaviour would reduce the chance of adult weevils being associated with ginger consignments.
- The main risk would be from rhizomes in which eggs were laid late in the season, just before harvest, or after harvest during storage. The Fiji ginger weevil is noted as a long-term storage pest in other root crops such as yams (*Dioscorea* spp.) (Wilson 1987).
- Adult weevils are dark brown to black, and 6–8 mm long (Mau and Martin Kessing 1992a). These would likely be found during pre-export processing or at quarantine inspection.
- The larvae are legless, of a creamy-white colour, with a distinct brown head. They are about 12 mm long when full size, and rather plump (Miller 1923). Larvae may be imported inside the rhizomes, making detection difficult. However, affected rhizomes may show external signs of rot.
- Ginger weevils have been intercepted in New Zealand in consignments of fresh ginger imported from Fiji. At least six ginger weevil specimens and a further two unidentified *Elytroteinus* spp. were found between 2000 and 2011 (interception data provided by NZMAF).
- Ginger weevils have been intercepted in the United States in sweet potato tubers in interstate movements from Hawaii (Shea 2004). *Elytroteinus subtruncatus* is a regulated plant pest in the USA (APHIS 2000).
- At least one Australian interception of this weevil has been noted, in Sydney, on unspecified goods from Fiji in 1963 (APPD 2011).

Probability of distribution

The likelihood that *Elytroteinus subtruncatus* will be distributed within Australia in a viable state to a susceptible part of a host, as a result of the processing, sale or disposal of fresh ginger from Fiji, is: **MODERATE**.

- The weevil larva will remain within the ginger rhizome for some time, as pupation occurs at the feeding site inside the ginger (Mau and Martin Kessing 1992a). Emergence of adult weevils may not occur until some time after arrival in Australia.
- Ginger will be distributed to many localities by wholesale and retail trade and by individual consumers.
- Individual consumers could carry small quantities of ginger rhizomes to urban, rural and natural localities. Small amounts of ginger waste could be discarded in these localities.
- Some ginger will be distributed to areas where ginger or other host species such as taro, lemons, avocado or sugarcane grow. Potential host plants are common in many populated areas of Australia.
- Small amounts of ginger waste will be discarded into domestic compost.
- Infested rhizomes that escaped detection during pre-export processing and importation are likely to be distributed in the wholesale and retail supply chain.

- *Elytroteinus* spp. weevils are flightless (NZ MAF 2008) and have a limited ability to seek out new hosts once they leave the rhizome.
- An infested ginger rhizome could be planted by a consumer, potentially providing a living host for the developing weevil. However, signs of weevil infestation such as tunnels, frass or rotting would lessen the likelihood that affected rhizomes would be used as planting material.
- The adults of other species of Cryptorhynchinae are known to live for up to two years and to hibernate or aestivate when suitable host plants are not available (Woodruff and Fasulo 2009).

Probability of entry (importation × distribution)

The likelihood that *Elytroteinus subtruncatus* will enter Australia and be transferred in a viable state to a susceptible host, as a result of trade in fresh ginger from Fiji, is: **MODERATE**.

4.1.2 Probability of establishment

The likelihood that *Elytroteinus subtruncatus* will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to their survival and reproduction, is: **LOW**.

- On lemons, Miller (1923) reported that only a single egg was laid in each fruit, so the fruit only contained a single larva. It is not known if this behaviour also occurs on ginger rhizomes, but it is considered likely.
- For this pest to establish, it would need to complete its lifecycle. This could occur if several infested rhizomes remained together in the supply chain (or were planted together in the same garden), or if a single rhizome carried several eggs (oviposited by multiple females, as each female probably lays only a single egg in the rhizome), the pupae emerged, the adults survived and mated, and several females found suitable plants for their eggs. The combined probability of all these events happening is considered to be low.

4.1.3 Probability of spread

The likelihood that *Elytroteinus subtruncatus* will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **MODERATE**.

- *Elytroteinus* spp. weevils are flightless (NZ MAF 2008), so natural spread would be slow. Longer distance spread would only occur via movement of infested produce.
- Climatic conditions in northern Australia are similar to that throughout the natural range of this weevil in the Pacific, so some spread could be anticipated.
- Host plants such as avocado, lemon, sugarcane and taro are common in some parts of Australia.
- The ginger weevil could be spread widely throughout Australia via the movement of other commodities such as lemon and avocado.
- *Elytroteinus subtruncatus* has not spread widely in Hawaii since it was first reported in 1918, despite the presence of host plants such as avocado and taro (Follet *et al*. 2007).

- The Fiji ginger weevil does not appear to be a particularly aggressive pest, and is likely to be limited in its spread by normal crop management techniques imposed as part of the growing cycle.

4.1.4 Probability of entry, establishment and spread

The likelihood that *Elytroteinus subtruncatus* will be imported as a result of trade in fresh ginger from Fiji, be distributed in a viable state to a susceptible host, establish and spread within Australia, is: **LOW**.

4.1.5 Consequences

Assessment of the potential consequences (direct and indirect) of *Elytroteinus subtruncatus* for Australia is: **VERY LOW**.

Criterion	Estimate and rationale
Direct	
Plant life or health	**Impact score**: C – minor significance at the district level The larval stage of this weevil burrows into the root, corm, or tuber of the host plant. The subsequent feeding results in stem dieback, leaf wilting, loss of vigour and rotting of the host. If feeding is extensive, the host plant dies (Mau and Martin Kessing 1992a; Fakalata 1981). It has been noted as a major pest of kava (Fakalata 1981) and begonia (Simmonds 1928), and can be a minor pest of other crops such as avocado, lemon and sugarcane (Follett *et al*. 2007).
Other aspects of the environment	**Impact score**: A – indiscernible at the local level There are no known direct consequences of this weevil on the natural or built environment.
Indirect	
Eradication, control etc.	**Impact score**: B – minor significance at the local level Control measures in the field and packing shed are confined to hygiene measures (removal of affected plants etc). The USA uses irradiation (400 Gy, 40 krad) to incidentally control this weevil in imports of sweet potato tubers from Hawaii, although these measures are principally aimed at two more serious pests, sweet potato scarabee and sweet potato stem borer (Shea 2004).
Domestic trade	**Impact score**: B – minor significance at the local level A small effect on domestic trade in ginger could be expected, with the need for quality controls and perhaps limitations on movement of ginger. Other crops such as lemons and sugar cane, and horticultural trade in *Dracaena* and *Cordyline* spp. might be affected, although of only minor significance.
International trade	**Impact score**: B – minor significance at the local level Any impact is likely to be via other crops, where some restrictions might be imposed. *Elytroteinus subtruncatus* is a regulated plant pest in the United States (APHIS 2000), and mainland USA has measures for ginger, sweet potato and taro imports from Hawaii due to ginger weevil (Follett *et al*. 2007).
Environmental and non-commercial	**Impact score**: A – indiscernible at the local level No information was found indicating possible indirect effects on the environment.

4.1.6 Unrestricted risk estimate

The unrestricted risk for *Elytroteinus subtruncatus* is: **NEGLIGIBLE**.

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

The unrestricted risk estimate for the *Elytroteinus subtruncatus* of 'negligible' achieves Australia's ALOP. Therefore, specific risk management measures are not required for this pest.

4.2 Yam scale

Aspidiella hartii

Aspidiella is a genus of armoured (or hard) scales (Hemiptera: Diaspididae) of eight species, distributed in the tropical regions of the world (Ben-Dov *et al*. 2011). *Aspidiella hartii* has been reported in Fiji (Ben-Dov *et al*. 2011; Wilson and Evenhuis 2007). Little is known of the lifecycle or biology of *Aspidiella hartii* (Watson 2011). *Aspidiella hartii* is known to feed on ginger rhizomes (Mau and Martin Kessing 1992b).

Members of the Diaspididae family are called armoured scales because they produce a hard, fibrous, wax-like covering (Carver *et al*. 1991) that attaches them to the host plant. Unlike the soft scales, armoured scales do not produce the honeydew-like secretions that commonly cause sooty mould to develop (Beardsley and Gonzalez 1975).

Feeding by armoured scales affects their hosts by removing sap, and injected saliva contains toxic enzymes that can damage the host plant (Beardsley and Gonzalez 1975). Leaf chlorosis and other localised effects are often associated with armoured scale infestations (Beardsley and Gonzalez 1975). High populations of scales can cause the death of branches or even entire trees (Beardsley and Gonzalez 1975; Watson 2011).

Scale nymphs typically settle and feed on the host plant, becoming immobile as they develop into late instar nymphs (Beardsley and Gonzalez 1975). The female reaches sexual maturity without undergoing true metamorphosis, remaining legless and immobile on the host plant. There is no pupal stage in the female lifecycle. The male scale has a pupal stage, subsequently emerging as a winged adult form. The female life stages are egg, nymph and adult, while the male has egg, nymph, pre-pupal, pupal and adult stages (Beardsley and Gonzalez 1975).

The scale covering the mature adult female *Aspidiella hartii* is circular, brown to brownish grey, and around 1–2.5 mm in diameter (Mau and Martin Kessing 1992b; Watson 2011). The scale cover of the mature male is smaller and more elongate than that of the female (Watson 2011). The adult males of most armoured scales are winged and capable of flight. They are tiny, fragile and lack functional mouthparts, so cannot feed. They are short-lived, generally living for only a few hours (Beardsley and Gonzalez 1975).

Reproduction in most armoured scales is sexual, although some reproduce by parthenogenesis, and some species have both sexual and parthenogenetic races (Beardsley and Gonzalez 1975; Watson 2011). *Aspidiella hartii* reproduces sexually (Mau and Martin Kessing 1992b; Watson 2011). After fertilization, the female starts to lay eggs under her scale.

Crawlers, which are the first nymphal instar, are the primary dispersal stage and move to new areas of the plant, or are dispersed further by wind, or via contact with flying insects or birds (Watson 2011). The crawlers can move up to a metre under their own locomotion (Watson 2011). At the end of the wandering period (dispersal phase), crawlers secure themselves to the host plant with their mouthparts. Once settled, the larvae draw their legs beneath the body and flatten themselves against the host (Koteja 1990). They then insert their piercing and sucking mouthparts into the plant tissue and start feeding on plant juices (Beardsley and Gonzalez 1975; Koteja 1990).

4.2.1 Probability of entry

Probability of importation

The likelihood that *Aspidiella hartii* will arrive in Australia with the importation of fresh ginger from Fiji is: **HIGH**.

- *Aspidiella hartii* may be found on ginger rhizomes (Stout 1982; Mau and Martin Kessing 1992b) and is likely to survive transport on ginger.
- *Aspidiella hartii* is a major pest during storage of ginger rhizomes (Devasahayam and Abdulla Koya 2005).
- *Aspidiella hartii* was the most commonly detected ginger pest intercepted in New Zealand on fresh ginger imported from Fiji between 2000 and 2010 (NZ pest interception data).
- Only first instar crawlers and male adults are active, which are likely to be dislodged during harvest and processing.
- Other stages are sessile under a protective scale and unable to move.
- Adult males do not live for more than a day, so are not likely to be present on imported ginger rhizomes, unless they emerge from pupation during transit.
- Eggs are laid within the puparium (scale) (Mau and Martin Kessing 1992b) and may remain intact during processing and transit if not detected.
- The harvested ginger is individually washed with high pressure water to remove soil, and this may remove some scales present on the ginger. However, live Diaspididae scales are difficult to remove with high pressure water spray, and a small percentage are likely to remain attached (Walker *et al*.1999).
- Armoured scales are small and may not be noticed at harvest or during pre-export processing, particularly when present in low numbers. Adult females of *Aspidiella hartii* are light brown to grey and are around 1 mm in diameter (Mau and Martin Kessing 1992b).

Probability of distribution

The likelihood that *Aspidiella hartii* will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of fresh ginger from Fiji, is: **HIGH**.

- The first-stage larvae of armoured scales are the active crawlers, while the second-stage larvae, pupae and adult females are immobile (Mau and Martin Kessing 1992b). *Aspidiella hartii* eggs, larvae, pupae and adult females would remain fixed to rhizomes under their protective scales.
- If viable eggs hatch whilst the ginger is in storage, the first instar crawlers may be able to spread to other products in the storage facility.
- Although the ginger is intended for human consumption, some material will be discarded as waste. Disposal of waste is likely to be via municipal or commercial waste systems, where pests would have limited opportunity to be in the proximity of host plants.
- Some ginger may be discarded in a domestic garden or other exposed outdoor environment where potential hosts may be present.
- Hosts of *Aspidiella hartii* include sweet potato, taro, turmeric and yams (Watson 2011).

- Crawler wandering generally serves to disperse young scales away from the mother onto new growth of the same host, and movement between plants seldom occurs unless such plants are in contact (Beardsley and Gonzalez 1975). Diaspid crawlers can only move for short distances, and with great difficulty, across sand or bare soil (Beardsley and Gonzalez 1975).
- The period of crawler mobility is limited by their small energy reserves and need to feed (Beardsley and Gonzalez 1975).
- Given the immobility of *Aspidiella hartii* during most of the life stages, the probability of a scale finding a suitable new host is moderate.
- However, if rhizomes infested with yam scales were planted and established, then the scales would have a high likelihood of having available host plants on which to establish.

Probability of entry (importation × distribution)

The likelihood that *Aspidiella hartii* will enter Australia and be transferred in a viable state to a susceptible host, as a result of trade in fresh ginger from Fiji, is: **HIGH**.

4.2.2 Probability of establishment

The likelihood that *Aspidiella hartii* will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **MODERATE**.

- The main risk for establishment is posed by the first instar larvae, as they are capable of seeking out suitable hosts over short distances if introduced into the environment.
- First instar larvae may be blown off the ginger during transport. However, the likelihood of these larvae landing on or near suitable hosts via wind dispersal would be very low.
- *Aspidiella hartii* is thought to reproduce sexually (Watson 2011), like most other armoured scales (Beardsley and Gonzalez 1975).
- Adult males of sexually reproducing Diaspididae may have flight capability, but are unable to establish populations (Moran and Goolsby 2010).
- Adult males only live for a few hours, so have a limited period in which to find a mate.
- An imported single gravid female may be all that is necessary to initiate an infestation (Beardsley and Gonzalez 1975). However, establishment of a population would require both male and female crawlers to find hosts in close proximity and complete their development, and then for the flying adult male to locate an adult female for mating.
- Receptive adult female scales release pheromones to attract males. Information on flight ability of male *Aspidiella hartii* is not available, but the males of California red scale (*Aonidiella aurantii*) have been recovered up to 189 m downwind and 92 m upwind from release points. However, they were unable to fly upwind when the wind velocity exceeded 1.6 km per hour (Beardsley and Gonzalez 1975).
- Cold winter temperatures are likely to be a limiting factor in the potential establishment of *Aspidiella hartii* (Soltic and Peacock 2006). Climatic conditions, particularly temperature, humidity and rainfall, influence the rate of development and survival of armoured scale species (Beardsley and Gonzalez 1975).

4.2.3 Probability of spread

The likelihood that *Aspidiella hartii* will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **HIGH**.

- Once established, *Aspidiella hartii* is likely to spread wherever suitable host plants and favourable climate occur.
- Natural spread would occur slowly through the movement of crawlers blown by the wind or carried by flying insects or birds (Watson 2011), although specific information on movement of *Aspidiella hartii* is lacking.
- Dispersal of crawlers via wind or animals is not directional, reducing the likelihood of the crawlers locating a suitable host.
- First instar crawlers of Diaspididae have limited ability to move unassisted. In the absence of wind or other assisted dispersal, crawlers normally settle on the same host plants as the parents (Magsig-Castillo *et al*. 2010).
- The movement of infested tubers or rhizomes of tropical root crops, especially if they are used for planting purposes or stored with other root crops to be used for planting, is the most likely means of long distance dispersal for *Aspidiella hartii* (Watson 2011).
- The small size and sessile habits of this species mean that an infestation may not be discovered until it is too late to eradicate it (Beardsley and Gonzalez 1975).

4.2.4 Probability of entry, establishment and spread

The likelihood that *Aspidiella hartii* will be imported as a result of trade in fresh ginger from Fiji, be distributed in a viable state to a susceptible host, establish and spread within Australia, is: **MODERATE.**

4.2.5 Consequences

Assessment of the potential consequences (direct and indirect) of *Aspidiella hartii* for Australia is: **LOW.**

Criterion	Estimate and rationale
Direct	
Plant life or health	**Impact score**: D – significant at the district level The scale insects feed on the phloem of hosts. Feeding damage from individual scales is minor, but large populations may develop, resulting in yellowing, defoliation, reduction in fruit set and loss of plant vigour (Mau and Martin Kessing 1992b). Symptoms may not appear on foliage or stems, although stunted growth may result from heavy infestations (Watson 2011).
Other aspects of the environment	**Impact score**: B – minor significance at the local level Given the limited host range of *Aspidiella hartii*, and that it mostly attacks roots and tubers, it is unlikely to have direct effects on the environment such as changing the plant community structure.
Indirect	
Eradication, control etc.	**Impact score**: B – minor significance at the local level Programs to control this pest are unlikely to involve major expense. Control procedures for endemic scale species may be effective. *Aspidiella hartii* has been eradicated from Hawaii (Mau and Martin Kessing 1992b), although details of the eradication program are not available.

Criterion	Estimate and rationale
Domestic trade	**Impact score**: C – minor significance at the district level Some ginger might be destroyed in storage or may not be saleable if the infestation was severe.
International trade	**Impact score**: B – minor significance at the local level Australia's export trade in ginger and other root crops such as taro and yams is small. *Aspidiella hartii* is unlikely to have a significant impact on international trade.
Environmental and non-commercial	**Impact score**: A – indiscernible at the local level No information was found indicating possible indirect effects on the environment.

4.2.6 Unrestricted risk estimate

The unrestricted risk for *Aspidiella hartii* is: **LOW.**

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

The unrestricted risk estimate for *Aspidiella hartii* of 'low' exceeds Australia's ALOP. Therefore, specific risk management measures are required for this pest.

4.3 Ring nematodes

Discocriconemella discolabia; *Mesocriconema denoudeni*

These two ring nematode species (Tylenchida: Criconematidae) have been grouped together because of their similar biology. They are predicted to pose a similar risk and require similar mitigation measures.

The lifecycles and biology of these species are not well documented. The ring nematodes are exclusively root-parasitic, feeding externally on the root surface (Siddiqi 2000). Only females and juveniles are found feeding on plant roots, as the adult males do not have a stylet. Ring nematodes are usually less than 1 mm in size, and are free-living in the soil (Raski and Luc 1987). They show marked sexual dimorphism, with females being cylindrical or sausage-shaped, and males smaller, vermiform and slender (Siddiqi 2000).

Ring nematodes are polyphagous, and may be found among the roots of a number of host plants. *Discocriconemella discolabia* has been recorded on more than 20 plant hosts (Orton Williams 1980), including yam, pawpaw and sweet potato. *Mesocriconema denoudeni* has been recorded on more than 65 plant hosts (Orton Williams 1980), including cabbage, capsicum, pawpaw, watermelon, lime, tomato, mango, avocado and sugarcane. It has also been reported as a minor pest of banana in Malaysia, but it is less common than many other nematode species associated with banana (Hassan 2005).

There is some contention over the use of the *Mesocriconema*, *Macroposthonia*, *Criconemella*, and *Criconemoides* genera names. *Criconemoides* Taylor, 1936 was the name originally given to the ring nematodes, but the large size of this genus led De Grisse and Loof (1965) to divide it into several genera, including *Macroposthonia* de Man, 1880 and *Criconemella* De Grisse and Loof, 1965. Luc and Raski (1981) rejected the *Macroposthonia* interpretation and transferred its species to *Criconemella* De Grisse and Loof 1965. Siddiqi (2000) has disputed this revision, and considers the *Macroposthonia* name to be valid. He has argued that the presence of submedian lobes can distinguish *Macroposthonia* species from the other genera in the Criconematidae family (Siddiqi 2000). Loof and De Grisse (1989) replaced the generic name *Macroposthonia* with the oldest available synonym *Mesocriconema* Andrássy 1965, and revalidated *Criconemoides* to replace *Criconemella* (Brzeski *et al*. 2002a; 2002b).

4.3.1 Probability of entry

Probability of importation

The likelihood that these ring nematodes will arrive in Australia with the importation of fresh ginger from Fiji is: **LOW**.

- Ring nematodes are ectoparasitic, and feed on the root cortex of host plants, with the anterior of the body thrust into the tissue (Siddiqi 2000).
- Ring nematodes are common in sandy soil and in soils with a high pH (Siddiqi 2000). Nematodes live in the soil around the roots and rhizome of the ginger plant, and so may be present when the ginger is harvested.
- Ring nematodes are migratory ectoparasites that feed on the roots of the host plant (Siddiqi 2000; Raski and Luc 1987). They do not enter the plant tissues, but feed by using

their stylet to puncture the plant cells (Luc *et al.* 1990). Ring nematodes would not typically feed on the rhizome.

- Adult male ring nematodes do not have a stylet and are incapable of tissue feeding (Siddiqi 2000), so will not be physically attached to the ginger. However, the stylet is present in fourth-stage juvenile males (Raski and Luc 1987), and so male juveniles may be present.
- *Discocriconemella discolabia* is widespread in Fiji, but populations are localised (Orton Williams 1980).
- *Discocriconemella discolabia* females are small, 0.24–0.30 mm long (Raski and Luc 1987).
- *Mesocriconema* species nematodes are small, 0.30–0.78 mm long (Siddiqi 2000).
- The small size of these nematodes means nematodes would escape detection during a visual inspection.
- Processing removes the roots from the harvested ginger. The rhizomes are also washed individually with high-pressure water to remove any soil. This would likely remove any ring nematodes present on the surface of the ginger. Given their ectoparasitic feeding behaviour on the roots, these nematodes are unlikely to be present on the rhizomes when harvested. These nematodes would not be present inside the rhizomes.

Probability of distribution

The likelihood that these ring nematodes will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of fresh ginger from Fiji, is: **LOW**.

- Dispersal over long distances is most likely to occur with transport of moist soil. As the ginger is washed to remove soil prior to export, the rhizomes should be free of soil.
- Ring nematodes are ectoparasitic root feeders (Siddiqi 2000), and so are unlikely to be present inside the rhizomes.
- In the absence of soil and moisture, ring nematodes would be susceptible to desiccation during distribution.
- Imported ginger may be widely distributed within Australia via retail distribution to supermarkets and greengrocers, and by individual consumers.
- Consumers will carry small quantities of ginger to urban, rural and natural localities. Small amounts of ginger waste could be discarded in these localities.
- Some ginger may be distributed to areas where ginger and other host plant species grow.
- Small amounts of ginger waste could be discarded in domestic compost.
- Living nematodes in discarded ginger waste may be able to find a compatible host in the area where they are discarded, but their ability to move from the rhizome to locate a new host is very limited, and dependant on factors such as soil moisture.
- While ring nematodes would have limited capacity to survive on rhizomes in the absence of soil and moisture, some nematodes could potentially be introduced to the soil if consumers planted rhizomes in backyard gardens. Nematodes would be vulnerable to attack by nematophagous fungi and other microorganisms in the soil. Once roots formed and the ginger established, the nematodes would have a living host on which to feed.
- Active movement of nematodes in the soil is probably limited to several centimetres per year. Movement is dependent on moisture, and will be affected by rainfall, soil texture,

compaction and structure, and slope position (Norton and Niblack 1991). Longer distance movement may occur via surface water or wind (Norton and Niblack 1991).

Probability of entry (importation × distribution)

The likelihood that these ring nematodes will enter Australia and be transferred in a viable state to a susceptible host, as a result of trade in fresh ginger from Fiji, is: **VERY LOW**.

4.3.2 Probability of establishment

The likelihood that these ring nematodes will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to their survival and reproduction, is: **HIGH**.

- Ring nematodes feed on the roots of a broad range of plants.
- *Mesocriconema denoudeni* is polyphagous and has been recorded on more than 65 plant hosts (Orton Williams 1980), many of which are present in Australia, including cabbage, capsicum, pawpaw, watermelon, lime, tomato, mango, avocado and sugarcane.
- *Discocriconemella discolabia* is polyphagous and has been recorded on more than 20 plant hosts (Orton Williams 1980), many of which are present in Australia, including yam, pawpaw and sweet potato.
- There is a low probability that these nematodes would be able to reproduce amphimictically in Australia, because adult males are non-feeding and unlikely to be introduced with imported ginger, provided the ginger is free of soil. The male's only function is to inseminate the female and then die (Siddiqi 1980). Only inseminated females present a risk.
- However, most *Mesocriconema* species are parthenogenetic (Luc *et al.* 1990), and so could establish a population without sexual reproduction.
- Climatic conditions in some parts of Australia will match those of the source areas in Fiji.

4.3.3 Probability of spread

The likelihood that these ring nematodes will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pests, is: **HIGH**.

- Plant parasitic nematodes require at least a film of water to enable locomotion, and so the soil water content is a primary ecological factor (Luc *et al*. 1990).
- These nematodes are most likely to be spread through the movement of infested soil, particularly on farm equipment and plant material.
- Ring nematodes move sluggishly, crawling like a worm by the lengthening and shortening of the body annules (Siddiqi 2000). Dispersal over long distances is most likely to occur with transport of moist soil.
- If these nematodes established in growing areas, it is possible that they could remain undetected for some time, initially causing little noticeable damage, and may be inadvertently spread via planting stock.
- Spread is also possible by transfer to alternative hosts and propagation via that pathway.
- Natural spread would be slow, relying on dispersal by water. Nematodes only actively move several centimetres per year (Norton and Niblack 1991).

4.3.4 Probability of entry, establishment and spread

The overall likelihood that these ring nematodes will be imported as a result of trade in fresh ginger from Fiji, be distributed in a viable state to a susceptible host, establish and spread within Australia, is: **VERY LOW**.

4.3.5 Consequences

Assessment of the consequences (direct and indirect) of these ring nematodes for Australia is: **LOW**.

Criterion	Estimate and rationale
Direct	
Plant life or health	**Impact score**: D – significant at the district level Ring nematodes are highly polyphagous (Orton Williams 1980). Feeding by ring nematodes (*Mesocriconema* spp.) can introduce bacterial pathogens, such as *Pseudomonas syringae*, into the host plant. Feeding can impair root functions such as uptake of nutrients and water (Westerdahl 2007). Plants may be weakened by nematode feeding, and susceptible to other pests and pathogens. Ring nematodes are chronic pests of turf grasses on golf courses (CABI 2011). Most recorded hosts are crop plants. Little information is available on the susceptibility of native plants to ring nematodes.
Other aspects of the environment	**Impact score**: A – indiscernible at the local level Ring nematodes are unlikely to have significant impacts on the environment.
Indirect	
Eradication, control etc.	**Impact score**: C – minor significance at the district level Once established, eradication of these species would not be possible. Control measures would be aimed at ensuring nematode-free planting stock.
Domestic trade	**Impact score**: B – minor significance at the local level Ring nematodes are ectoparasites of plant roots, and so are unlikely to have an adverse impact on consumer demand or market access for fresh produce. *Mesocriconema* (*Criconemella*) species are very common in forest tree roots and in the soil in tree nurseries, although their economic importance is not clear (CABI 2011). Economic impact on commercial orchard crops is more apparent (CABI 2011). Ring nematodes can become a nuisance on certain crops when large populations build up (Siddiqi 2000).
International trade	**Impact score**: B – minor significance at the local level The establishment of these ring nematodes in Australia may pose difficulties for access to some international markets for a limited number of commodities involving soil (e.g. nursery stock, as well as root and tuber crops). A number of other ring nematode species are already present in Australia. Establishment of additional species in Australia may create challenges for the export of root and tuber crops. However, production and post-harvest measures already used against other nematode pests would address concerns over these species, so this is unlikely to pose a significant additional burden on producers or exporters.
Environmental and non-commercial	**Impact score**: A – minor significance at the local level No indirect environmental consequences of these nematodes are known.

4.3.6 Unrestricted risk estimate

The unrestricted risk for ring nematodes is: **NEGLIGIBLE**.

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

The unrestricted risk estimate for ring nematodes of ‘negligible’ achieves Australia’s ALOP. Therefore, specific risk management measures are not required for this pest.

4.4 Spiral nematodes

Helicotylenchus egyptiensis; *Helicotylenchus indicus*; *Helicotylenchus mucronatus*

These spiral nematode species (Tylenchida: Hoplolaimidae) have been grouped together because of their similar biology. They are predicted to pose a similar risk and require similar mitigation measures.

Helicotylenchus species are polyphagous plant parasitic root feeders that are found throughout tropical and subtropical regions of the world. The lifecycles and biology of these nematodes are not well documented. Most spiral nematodes are parthenogenetic (i.e. can reproduce without a male), but some reproduce by amphimixis (cross-fertilization, i.e. sexual reproduction by females and males) (Luc *et al*. 1990; Triantaphyllou and Hirschmann 1964).

Spiral nematodes are usually ectoparasitic feeders on roots, but they can sometimes feed inside the roots (Kazi 1996; Luc *et al.* 1990). All life stages can be found in the soil and root cortex, but migration through the root tissues has not been reported. Nematode feeding results in small lesions forming on the affected roots, which become necrotic as secondary infections occur (Luc *et al*. 1990).

Helicotylenchus is the most common plant nematode genus in Fiji (Orton Williams 1980). *Helicotylenchus egyptiensis*, *Helicotylenchus indicus* and *Helicotylenchus mucronatus* have been reported feeding on ginger. These species have not been reported in Australia (McLeod *et al*. 1994).

Helicotylenchus egyptiensis is a plant-parasitic nematode that feeds on the roots of cereals and fruit trees (Kazi 1996). Females are short with rather thick bodies. Males have not been recorded (Zeidan and Geraert 1990; Kazi 1996; Van den Berg and Kirby 1979). It is polyphagous, feeding on a number of plants (see Appendix B) that are common and widespread in Australia. *Helicotylenchus egyptiensis* is 0.56–0.85 mm in length (Zeidan and Geraert 1990).

Helicotylenchus mucronatus is a plant-parasitic nematode that is common in Fiji (Orton Williams 1980). It is highly polyphagous, with an extensive list of host plants (Orton Williams 1980) (see Appendix B), many of which are present in Australia. *Helicotylenchus mucronatus* is one of the major species within the spiral nematode group (Luc *et al*. 1990).

Helicotylenchus indicus is a weak parasite, which mainly affects the cortical tissues of vegetables. In India, this species was considered to cause economic damage to vegetable production when present at high population densities (Lamberti 1997). *Helicotylenchus indicus* is 0.54–0.71 mm in length (Kazi 1996).

A number of other spiral nematode species are known to be present in Australia, including *Helicotylenchus multicinctus*, which is a serious pest of banana and sugarcane (McLeod *et al*. 1994), and *Helicotylenchus erythrinae*, which has been reported in association with a number of plant hosts including rice, oats, citrus, banana, macadamia, coffee, sugarcane and avocado (Kazi 1996; CABI 2011; McLeod *et al*. 1994). *Helicotylenchus erythrinae* has been reported on ginger in Fiji (Kirby *et al*. 1980), but ginger has not been noted as a host in other surveys and literature (e.g. Orton Williams 1980; Bridge 1988). It is less commonly reported as a pest in the Pacific than other spiral nematodes, and is only of minor importance.

4.4.1 Probability of entry

Probability of importation

The likelihood that these spiral nematodes will arrive in Australia with the importation of fresh ginger from Fiji is: **LOW**.

- *Helicotylenchus* species are small to medium-sized nematodes (0.4–1.2 mm) (Siddiqi 2000), making detection difficult.
- While the lifecycle and biology of the three species being assessed is not well documented, they are likely to predominantly feed on the outside of the roots like most other spiral *Helicotylenchus* species (Kazi 1996).
- All life stages can be found in the root cortex of host plants, but migration through (i.e. inside) the root tissues has not been reported (Luc *et al.* 1990). Their association is with the roots, rather than the rhizome.
- Processing removes the roots from the harvested ginger. The rhizomes are also washed individually with high-pressure water to remove any soil prior to export. This would likely remove most spiral nematodes present on the surface of the ginger.
- Removal of feeder roots as part of the cleaning process and drying of the surface of the ginger rhizome and any remaining fine roots in storage will further reduce the numbers of nematodes.
- Eggs are laid free in the soil (Kazi 1996), and would not be attached to the ginger rhizome.
- The most likely pathway for entry would be via infested soil attached to poorly cleaned rhizomes.
- *Helicotylenchus* species are not typically carried on rhizomes, bulbs, tubers or corms in trade or transport (CABI 2011).

Probability of distribution

The likelihood that these spiral nematodes will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of fresh ginger from Fiji, is: **MODERATE**.

- These nematodes are not known to penetrate deeply into root tissue, instead remaining on or near the surface. As the outer surfaces of the rhizomes and the fine feeder roots dry in storage and during distribution, conditions for survival of the nematodes will become less favourable.
- If the environment dries slowly, nematodes may enter a reversible anhydrobiotic state where they are less susceptible to desiccation, temperature and chemicals (Luc *et al.* 1990). This dormancy is a state of stasis that allows survival in harsh conditions, called a 'dauer stage'. However, this is usually only initiated during a brief period of juvenile development. No development occurs during the dauer stage, and there is no feeding or defecation. Normal development resumes after recovery (Lewis and Pérez 2004).
- Dormant juvenile nematodes are unlikely to be attached to the ginger if it is free of soil.
- Many nematodes, including *Helicotylenchus* species, are also capable of coiling behaviour to improve the likelihood of surviving desiccation. Formation of a coil reduces the surface area of the cuticle exposed to the air, thus reducing the rate of water loss (Wharton 2004).

- Dispersal over long distances is most likely to occur in rhizomes accompanied by moist soil.
- Imported ginger will be distributed to many localities within Australia by wholesale and retail trade, and by individual consumers.
- Individual consumers could carry small quantities of ginger rhizomes to urban, rural and natural localities. Small amounts of ginger waste could be discarded in these localities.
- Some ginger rhizomes may be distributed to areas where host plants are grown.
- Small amounts of ginger waste will be discarded into domestic compost.
- *Helicotylenchus* species are polyphagous (Luc *et al.* 1990), increasing the likelihood that introduced nematodes could locate a suitable host. Known hosts such as sugarcane, oranges, lemons, carrots, oats, cabbages, potatoes, tomatoes, maize and onions (Zeidan and Geraert 1990; Van den Berg and Kirby 1979; Orton Williams 1980; Kazi 1996) are widespread and common.
- Nematodes in discarded ginger waste may be able to find a compatible host in the area where they are discarded, but their ability to move from the rhizome to locate a new host is very limited and dependant on factors such as soil moisture.
- Some spiral nematodes could potentially be introduced to the soil if consumers planted rhizomes in backyard gardens. Nematodes would be vulnerable to attack by nematophagous fungi and other microorganisms in the soil. Once roots formed and the ginger established, the nematodes would have a living host on which to feed.
- Active movement of nematodes in the soil is probably limited to several centimetres per year. Movement is dependent on moisture, and will be affected by rainfall, soil texture, compaction and structure, and slope position (Norton and Niblack 1991). Longer distance movement may occur via surface water or wind (Norton and Niblack 1991).

Probability of entry (importation × distribution)

The likelihood that these spiral nematodes will enter Australia and be transferred in a viable state to a susceptible host, as a result of trade in fresh ginger from Fiji, is: **LOW**.

4.4.2 Probability of establishment

The likelihood that these spiral nematodes will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to their survival and reproduction, is: **HIGH**.

- Climatic conditions in some parts of Australia will match those in the ginger production areas in Fiji.
- Most *Helicotylenchus* species reproduce parthogenetically (Luc *et al*. 1990), which would increase the likelihood of establishment.
- *Helicotylenchus dihystera* reproduces by mitotic parthogenesis (Triantaphyllou and Hirschmann 1967), and no fertilization is necessary for reproduction.
- Surveys by Van den Berg and Kirby (1979), Zeidan and Geraert (1990) and Kazi (1996) did not find any male *Helicotylenchus egyptiensis* and *Helicotylenchus indicus* nematodes.
- Spiral nematodes may not easily adapt to a different environment following introduction into a new habitat. *Helicotylenchus* populations are markedly reduced in biotypes uncharacteristic for them, and they may remain viable only in the climatic conditions to

which they are accustomed. Temperature is a fundamental factor restricting wide distribution of *Helicotylenchus* species (Krall 1990).

4.4.3 Probability of spread

The likelihood that these spiral nematodes will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pests, is: **HIGH**.

- Active spread would be slow, as nematodes only move several centimetres per year in the soil (Norton and Niblack 1991).
- Nematodes on the soil surface could be carried much greater distances by wind or surface water.
- Plant parasitic nematodes require at least a film of water to enable locomotion, and so the soil water content is a primary ecological factor (Luc *et al*. 1990).
- These nematodes are most likely to be spread through the movement of infested soil, particularly on farm equipment and plant material.
- *Helicotylenchus* species have some resistance to desiccation. These nematodes could survive in soil that was disturbed and moved to another site, and locate a new host.
- If a population established in a growing area it is possible that these nematodes could remain undetected for some time, initially causing little noticeable damage, and be inadvertently spread via movement of planting stock.
- Spread is also possible by transfer to alternative hosts and propagation via that pathway.

4.4.4 Probability of entry, establishment and spread

The overall likelihood that these spiral nematodes will be imported as a result of trade in fresh ginger from Fiji, be distributed in a viable state to a susceptible host, establish and spread within Australia, is: **LOW**.

4.4.5 Consequences

Assessment of the consequences (direct and indirect) of these spiral nematodes for Australia is: **LOW**.

Criterion	Estimate and rationale
Direct	
Plant life or health	**Impact score**: D – significant at the district level *Helicotylenchus* species have been associated with depression of plant growth (Wouts and Yeates 1994). Type species *Helicotylenchus dihystera* has been reported to produce chlorosis, stunted growth and sparsely developed roots in a range of host plants. They severely damage the root system of sugarcane when present in densities above 1000 nematodes per 500 g of soil, causing noticeable and significant reductions in plant growth (CABI 2011). Spiral nematode feeding also increases host susceptibility to infection by bacteria (particularly *Pseudomonas* sp.), and fungi such as *Phytophthora cinnamomi* (CABI 2011).
Other aspects of the environment	**Impact score**: A – indiscernible at the local level Spiral nematodes are unlikely to have significant impacts on the environment.

Criterion	Estimate and rationale
Indirect	
Eradication, control etc.	**Impact score**: C – minor significance at the district level Once established, eradication of these species would be difficult. Control measures would be aimed at ensuring nematode-free planting stock. There would be possible impact on other crops as these nematodes are not host-specific. However, the crops most at risk (bananas, sugarcane) are already subject to attack by *Helicotylenchus multicinctus*, a more serious pest, and efforts to control that species would simultaneously control these species. Treatment of planting material by immersion in hot water at 50 °C for 15–40 minutes has been shown to be effective in eliminating other nematode species from ginger planting material without damaging the planting stock (Luc *et al.* 1990).
Domestic trade	**Impact score**: B – minor significance at the local level Most *Helicotylenchus* spp. are considered mild pests of little economic importance, although hosts include sugarcane and various tubers (Manzanilla-López *et al*. 2004). *Helicotylenchus* spp. are often the most prevalent parasitic nematodes reported on rice in Africa and India, but there are few reports of associated damage (Bridge *et al*. 2005). They feed on a number of hosts that are commercially grown in Australia, but given the limited damage to the commodities, spiral nematodes are unlikely to have an adverse impact on domestic trade.
International trade	**Impact score**: B – minor significance at the local level Most *Helicotylenchus* spp. are considered mild pests of little economic importance, although hosts include sugarcane and various tubers (Manzanilla-López *et al*. 2004).
Environmental and non-commercial	**Impact score**: A – indiscernible at the local level No indirect environmental consequences of these nematodes are known.

4.4.6 Unrestricted risk estimate

The unrestricted risk for spiral nematodes is: **VERY LOW**.

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

The unrestricted risk estimate for spiral nematodes of ‘very low’ achieves Australia’s ALOP. Therefore, specific risk management measures are not required for this pest.

4.5 Cystoid nematode

Sphaeronema sp.

Cystoid nematodes (*Sphaeronema* spp.) are highly adapted obligate parasites of plant roots (Raski and Luc 1987; Siddiqi 2000). They are ectoparasitic feeders during their immature stages, but the adult females are endoparasites, feeding inside the root tissues of host plants (Siddiqi 2000).

The juvenile cystoid nematodes are slender and active, with a well-developed feeding stylet. The juveniles feed ectoparasitically until the final immature stage (Siddiqi 2000). The adult feeding site is probably initiated early in the final (fourth) juvenile stage, forming a syncytium of pericycle and phloem cells. The juvenile increases in size, transforming into a somewhat swollen preadult female in around seven days (Wouts 2006). In this last moult, the entire post-vulval region, including the superfluous tail, is lost, as it is not needed for the sedentary adult mode of life (Siddiqi 2000). The sessile female swells symmetrically and transforms into a spherical sac containing the feeding and reproductive organs (Siddiqi 2000). Once feeding commences, the nematode remains sedentary and develops to maturity embedded in the root tissue where it feeds (Raski and Luc 1987; Siddiqi 2000). The stylet and oesophageal pump are strongly developed for continuous feeding (Siddiqi 2000). Only the posterior part of the body remains exposed outside the root (Wouts 2006).

Information on the lifecycle and behaviour of *Sphaeronema* sp. in Fiji is not available, and little research appears to have been done on Sphaeronematidae in the Pacific, so much of this pest risk assessment is extrapolated from studies on *Sphaeronema* species in other regions. Cystoid nematodes are found in colonies (Siddiqi 2000), with females, males and juveniles all present (Wouts 2006). In *Sphaeronema sasseri*, often several groups of females will encircle the base of a single root (Eisenback and Hartman 1985). Feeder roots and ectomycorrhizae surrounded by large colonies are usually stunted or dead. These colonies may be hidden underneath sloughed layers of cortical cells (Eisenback and Hartman 1985). These nematodes rarely occur freely in the soil outside the rhizosphere (Eisenback and Hartman 1985).

There is no evidence of parthenogenetic reproduction reported. Mature female *Sphaeronema* nematodes are sub-spherical, 0.13–0.21 mm long (Siddiqi 2000). Immature female nematodes are pear-shaped, with a curved tail (Siddiqi 2000). Mature males have slender bodies, 0.39–0.47 mm in length, and the stylet and oesophagus are lacking (Siddiqi 2000; Wouts 2006). The males are non-feeding, and free-living in the soil (Raski and Luc 1987). Eggs are laid singly in a gelatinous matrix (Siddiqi 2000). In *Sphaeronema sasseri*, the eggs are deposited into a communal gelatinous matrix produced by several females. These egg masses have been found beneath layers of dead cortical root tissue where the sedentary adult females were discovered (Eisenback and Hartman 1985). After hatching, the juvenile nematodes may remain within the matrix, or migrate slowly to nearby root tissues (Eisenback and Hartman 1985).

A *Sphaeronema* sp. nematode has been reported in Fiji, Kiribati, Samoa and Tonga (Orton Williams 1980). It was not considered to be common, and was mainly found in uncultivated soils (Orton Williams 1980). It has been associated with a number of plant hosts in the Pacific, including pineapple, breadfruit, chilli, pawpaw, citrus, coconut, pumpkin, banana, sugarcane and yardlong bean (Orton Williams 1980). However, the unidentified nematodes identified in the Pacific surveys may represent more than one *Sphaeronema* species.

A survey of a farm at Veikoba in September 2007 conducted after planting of the new season ginger crop found a number of *Sphaeronema* nematodes (Smith *et al*. 2007). These nematodes were not identified to a species level. A random sample of 10 seed rhizomes from 8 plots was macerated and examined for presence of parasitic nematodes six days after planting. *Sphaeronema* were detected in three of eight plots (22, 14 and 70 nematodes respectively). No nematodes had been detected in the soil prior to planting, so it appears that the nematodes were introduced into prepared plots on seed that had been insufficiently hot-water treated (Smith *et al.* 2007). Although the numbers of nematodes found were relatively low, they nevertheless indicate a potential risk of importation and spread in ginger. However, seed rhizomes may have some roots still attached, unlike ginger rhizomes exported for human consumption.

An unidentified *Sphaeronema* nematode has been recorded on prickly pear in Queensland (McLeod *et al.* 1994). It is likely to be a different species to the one recorded on ginger in Fiji. *Sphaeronema californicum* is present in New Zealand (Wouts 2006).

4.5.1 Probability of entry

Probability of importation

The likelihood that *Sphaeronema* sp. will arrive in Australia with the importation of fresh ginger from Fiji is: **MODERATE**.

- Small numbers of *Sphaeronema* sp. nematodes have been found in ginger seed rhizomes used as planting material on a farm at Veikoba, Fiji (Smith *et al.* 2007). This nematode has not been reported on ginger in Fiji previously.
- No *Sphaeronema* spp. nematodes were detected in consignments of Fijian ginger exported to New Zealand between 2000 and 2011 (interception data provided by NZMAF).
- The nematodes are likely to be present in the roots and root base, rather than the rhizome itself. Roots should be removed during postharvest processing prior to export.
- Adult females could be present on any roots not removed from the rhizomes.
- The females are embedded in the root tissue, with only the posterior protruding from the surface, so may not be removed during postharvest cleaning processes.
- If any roots were present on the rhizomes, it is possible that some eggs, juveniles and males could be present, protected within a gelatinous matrix underneath sloughed layers of cortical cells (Eisenback and Hartman 1985).
- *Sphaeronema* spp. nematodes are very small and would be difficult to detect unless the roots were inspected under a microscope (Eisenback and Hartman 1985).
- *Sphaeronema* spp. nematodes live in colonies (Siddiqi 2000), which are more likely to be detected at inspection than single nematodes.
- Males are non-feeding, and free-living in the soil (Raski and Luc 1987), so are unlikely to be found on ginger that has been washed and free of all roots and soil.

Probability of distribution

The likelihood that *Sphaeronema* sp. will be distributed within Australia in a viable state, as a result of the processing, sale or disposal of fresh ginger from Fiji, is: **MODERATE**.

- Imported ginger will be distributed to many localities within Australia by wholesale and retail trade, and by individual consumers.

- Individual consumers could carry small quantities of ginger rhizomes to urban, rural and natural localities. Small amounts of ginger waste could be discarded in these localities.
- Some ginger rhizomes may be distributed to areas where host plants are grown.
- Small amounts of ginger waste will be discarded into domestic compost.
- *Sphaeronema* sp. has been reported on plant hosts from more than 20 genera (Orton Williams 1980), increasing the likelihood that introduced nematodes could locate a suitable host. Known hosts such as sugarcane, citrus, chilli, pawpaw, coconut, pumpkin and banana (Orton Williams 1980) are widespread and common.
- *Sphaeronema* spp. are obligate root parasites, and the adult females do not move once they have commenced feeding.
- Juveniles, adult males and eggs could survive within a gelatinous egg mass on the rhizome surface, or perhaps under dead layers of cortical cells. If they were in ginger waste material, they may be able to find a compatible host in the area where they were discarded. However, their ability to move from the rhizome to locate a new host is very limited and dependant on factors such as soil moisture.
- Active movement of nematodes in the soil is probably limited to several centimetres per year. Movement is dependent on moisture, and will be affected by rainfall, soil texture, compaction and structure, and slope position (Norton and Niblack 1991). Longer distance movement may occur via surface water or wind (Norton and Niblack 1991).
- Consumers could attempt to use ginger rhizomes as planting material in a garden, which may introduce juvenile nematodes, adult males and eggs into the soil. Once roots formed and the ginger established, the nematodes would have a living host on which to feed.

Probability of entry (importation × distribution)

The likelihood that *Sphaeronema* sp. will enter Australia and be transferred in a viable state to a susceptible host, as a result of trade in fresh ginger from Fiji, is: **LOW**.

4.5.2 Probability of establishment

The likelihood that *Sphaeronema* sp. will establish within Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **HIGH**.

- Climatic conditions in parts of Australia will match those in the ginger production areas in Fiji.
- *Sphaeronema* spp. live in colonies on the roots and in the rhizosphere, so it is likely that if nematodes were introduced on fresh produce, they may be numerous, which would increase the likelihood of establishment.
- Adult and juvenile males are unlikely to be imported unless they are within a gelatinous egg mass attached to root material.
- Female *Sphaeronema* spp. nematodes cannot reproduce by autokonous parthenogenesis (automixis). Descriptions of the *Sphaeronema* genus (Siddiqi 2000), and individual species such as *Sphaeronema californicum* (Wouts 2006) and *Sphaeronema sasseri* (Eisenback and Hartman 1985), do not indicate the presence of a spermatheca to produce ‘male’ gametes in females, which does occur in some nematode species. In the absence of males, any introduced female nematodes would be unable to amphimictically reproduce because males are necessary to fertilise the eggs.

- The most likely scenario for this nematode to successfully establish would be if an infested rhizome was used as planting material in a garden, which subsequently sprouted. This would greatly increase the likelihood of reproduction occurring, resulting in establishment of the species in Australia.

4.5.3 Probability of spread

The likelihood that *Sphaeronema* sp. will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **HIGH**.

- Plant parasitic nematodes require at least a film of water to enable locomotion, and so the soil water content is a primary ecological factor (Luc *et al*. 1990).
- These nematodes are most likely to be spread through the movement of infested planting material (Smith *et al*. 2007).
- It is possible that these nematodes could remain undetected for some time causing little damage, and be inadvertently spread via planting stock, if they established in growing areas.
- Spread is also possible by transfer to alternative hosts and propagation via that pathway.
- Active spread would be slow, as nematodes only move several centimetres per year in the soil (Norton and Niblack 1991).

4.5.4 Probability of entry, establishment and spread

The likelihood that *Sphaeronema* sp. will enter Australia as a result of trade in fresh ginger from Fiji, be distributed in a viable state to a susceptible host, establish and spread within Australia, is: **LOW**.

4.5.5 Consequences

Assessment of the consequences (direct and indirect) of *Sphaeronema* sp. for Australia is: **LOW**.

Criterion	Estimate and rationale
Direct	
Plant life or health	**Impact score**: D – significant at the district level The *Sphaeronema* sp. (or possibly spp.) in the Pacific has been found on a number of plant hosts (Orton Williams 1980).This nematode has rarely been found in surveys in Fiji, and has yet to be described. Information on the impacts of this species to plant health in Fiji or other Pacific countries is not reported, suggesting that it is possibly only of minor significance. The impact score for this criterion reflects the possibility that damage to plant health caused by this nematode may not have been reported, or incorrectly attributed to other pests. There are pest species in the genus elsewhere in the world. Other *Sphaeronema* spp. have been associated with the decline or death of trees. *Sphaeronema sasseri* has been reported to cause decline and dieback of red spruce and Fraser fir in North Carolina (Eisenback and Hartman 1985). A *Sphaeronema* sp. was suspected of playing a role in the deaths of large numbers of Alaskan cedar (Hennon *et al*. 1986). The main impact would be through a potential decline in production.
Other aspects of the environment	**Impact score**: A – indiscernible at the local level *Sphaeronema* sp. is unlikely to have significant impacts on the environment.

Criterion	**Estimate and rationale**
Indirect	
Eradication, control etc.	**Impact score**: C – minor significance at the district level Once established, eradication of this nematode would be difficult. Control measures would be aimed at ensuring nematode-free planting stock. Treatment of planting material by immersion in hot water at 50 °C for 15–40 minutes has been shown to be effective in eliminating other nematode species from ginger planting material without damaging the planting stock (Luc *et al.* 1990).
Domestic trade	**Impact score**: B – minor significance at the local level *Sphaeronema* sp. feeds on a number of plant hosts that are commercially grown in Australia, but given the limited damage to the commodities, it is unlikely to have an adverse impact on domestic trade. With the exception of ginger, and possibly pineapple, the nematodes are unlikely to be associated with the traded commodities (e.g. papaya fruit, coconuts, bananas, pumpkins), so interstate restrictions on the movement of these commodities from areas where *Sphaeronema* sp. was present would not be warranted.
International trade	**Impact score**: B – minor significance at the local level The establishment of *Sphaeronema* sp. in Australia may pose difficulties for access to some international markets for a limited number of commodities involving soil (e.g. nursery stock, as well as root and tuber crops). Production and post-harvest measures already used against other nematode pests are likely to address concerns over this species, so it is unlikely to pose an additional burden on producers or exporters.
Environmental and non-commercial	**Impact score**: A – indiscernible at the local level No indirect environmental consequences of *Sphaeronema* sp. are known.

4.5.6 Unrestricted risk estimate

The unrestricted risk for *Sphaeronema* sp. is: **VERY LOW**.

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

The unrestricted risk estimate for *Sphaeronema* sp. of 'very low' achieves Australia's ALOP. Therefore, specific risk management measures are not required for this pest.

4.6 Pest risk assessment conclusion

The unrestricted risk posed by *Aspidiella hartii* is estimated to exceed Australia's ALOP. Therefore, management measures for this pest are required to reduce the quarantine risk.

The unrestricted risk of the other pests assessed achieves Australia's ALOP and therefore risk management measures are not required.

The results of the risk estimates are summarised in Table 4.2. The rationale for each value of the pest risk assessment, summarised in this table, is described in the relevant sections above.

The proposed pest risk management measures are discussed in Section 5.

Key to Table 4.2 (over page)

Genus species [EP] pests for which policy already exists. The outcomes of previous assessments and/or reassessments in this IRA are presented in table 4.2

Genus species [state/territory] state/territory in which regional quarantine pests have been identified

Likelihoods for entry, establishment and spread

N	negligible
EL	extremely low
VL	very low
L	low
M	moderate
H	high
P[EES]	overall probability of entry, establishment and spread

Assessment of consequences from pest entry, establishment and spread

PLH	plant life or health
OE	other aspects of the environment
EC	eradication control etc
DT	domestic trade
IT	international trade
ENC	environmental and non-commercial
A-G	consequence impact scores are detailed in section 2.2.3
URE	unrestricted risk estimate. This is expressed on an ascending scale from negligible to extreme.

Table 4.2 Summary of unrestricted risk estimates for quarantine pests associated with fresh ginger from Fiji

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]								
	Importation	Distribution	Overall				Direct		Indirect				Overall	
							PLH	OE	EC	DT	IT	ENC		
Weevils [Coleoptera: Curculionidae]														
Elytroteinus subtruncatus	H	M	M	L	M	L	C	A	B	B	B	A	VL	**N**
Armoured scales [Hemiptera: Diaspididae]														
Aspidiella hartii	H	H	H	M	H	M	D	B	B	C	B	A	L	**L**
Ring nematodes [Tylenchida: Criconematidae]														
Discocriconemella discolabia *Mesocriconema denoudeni*	L	L	VL	H	H	VL	D	A	C	B	B	A	L	**N**
Spiral nematodes [Tylenchida: Hoplolaimidae]														
Helicotylenchus egyptiensis *Helicotylenchus indicus* *Helicotylenchus mucronatus*	L	M	L	H	H	L	D	A	C	B	B	A	L	**VL**
Cystoid nematodes [Tylenchida: Tylenchulidae]														
Sphaeronema sp.	M	M	L	H	H	L	D	A	C	B	B	A	L	**VL**

5 Pest risk management

This chapter describes the phytosanitary procedures associated with the importation of fresh ginger rhizomes from Fiji, and provides information on the management of quarantine pests identified with an unrestricted risk exceeding Australia's appropriate level of protection (ALOP). The proposed phytosanitary measures are described below.

5.1 Pest risk management measures and phytosanitary procedures

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests for Australia where they have been assessed to have an unrestricted risk above Australia's ALOP. In calculating the unrestricted risk, existing commercial production practices in Fiji have been considered, as have postharvest procedures and the packing of ginger rhizomes.

In addition to Fiji's existing commercial production practices for the production of ginger and minimum border procedures in Australia, specific pest risk management measures are proposed to achieve Australia's ALOP. Finalisation of the quarantine conditions may be undertaken with input from DAFF Biosecurity and the Australian states and territories as appropriate.

5.1.1 Management for yam scale

The yam scale *Aspidiella hartii* has been assessed to have an unrestricted risk estimate of 'low' for ginger rhizomes imported from Fiji. This exceeds Australia's appropriate level of protection (ALOP). Therefore, additional phytosanitary measures are required to manage this risk.

The major risk from *Aspidiella hartii* is the importation of live scales on ginger rhizomes that are subsequently diverted from their intended use for human consumption and used as planting material. Infested rhizomes could also be discarded in the vicinity of suitable host plants, although most life stages are immobile and unlikely to establish.

The proposed risk management measure is:

- inspection to ensure that ginger rhizomes infested with *Aspidiella hartii* are identified and subjected to appropriate remedial action.

This risk management measure is consistent with Australia's quarantine policy for scale species on other imported commodities.

5.1.2 Operational system for the maintenance and verification of phytosanitary status

A system of operational procedures is necessary to maintain and verify the phytosanitary status of fresh ginger from Fiji.

Provisions for traceability

All consignments must have adequate labelling or other means of identification so that they can be traced to critical points of the pathway.

Registration of export farms

The objectives of this proposed procedure are to ensure that:

- fresh ginger is sourced from registered commercial export farms producing ginger rhizomes, as the pest risk assessments are based on standard commercial production and harvesting activities
- farms from which export ginger is sourced can be identified so investigation and corrective action can be targeted rather than applying to all contributing export farms in the event that live pests are regularly intercepted during on-arrival inspection.

Registration of packing house

The objectives of this proposed procedure are to ensure that:

- ginger rhizomes are sourced from commercial packing houses, as the pest risk assessments are based on standard commercial packing activities
- packing houses from which ginger is exported can be identified so investigation and corrective action can be targeted rather than applying to all contributing packing houses if live pests or other regulated articles are regularly intercepted during on-arrival inspection.

Packaging and labelling

The objective of the requirement for packaging and labelling are to ensure that:

- fresh ginger exported to Australia is not contaminated by quarantine pests or regulated articles (e.g. trash, ants, soil and weed seeds)
- unprocessed packing material (which may vector pests not identified as being on the pathway) is not imported with the ginger rhizomes
- all wood used in the packing of the commodity complies with relevant DAFF Biosecurity conditions (see the publication 'Cargo containers: Quarantine aspects and procedures')
- secure packaging is used.

Specific conditions for storage and transport

The objective of the requirement for storage and transport are to ensure that:

- product for export to Australia is secure to prevent mixing or cross-contamination with produce destined elsewhere
- maintain the quarantine integrity of the commodity during storage and movement.

Pre-export phytosanitary inspection and certification

The objectives of phytosanitary certification are to ensure that:

- an International Phytosanitary Certificate (IPC) is issued for each consignment, consistent with ISPM No. 12 Guidelines for Phytosanitary Certificates (FAO 2001), to provide formal documentation to DAFF Biosecurity verifying the relevant measures have been undertaken offshore

- ensure the goods have been inspected for quarantine pests and other regulated articles by the NPPO
- each IPC includes a description of the consignment (including grower number and packing house details).

Additional Phytosanitary Certificate declaration

Each consignment must be accompanied by an original IPC endorsed with the following additional declaration:

> The ginger rhizomes have been inspected and found to be free of yam scale (*Aspidiella hartii*).

On-arrival DAFF Biosecurity inspection

DAFF Biosecurity officers will undertake an inspection of all ginger consignments covered by separate phytosanitary certificates issued by the NPPO on arrival of the consignment in Australia. The inspection will be conducted using the standard inspection regime for the type of commodity and may involve specific techniques or use of optical enhancement where necessary.

The detection of live quarantine pests or regulated articles during an inspection will result in the failure of the inspection lot.

The objectives of this procedure are to ensure that:

- each consignment as defined by a single phytosanitary certificate, is inspected at the first port of entry for quarantine pests and regulated articles
- consignments are inspected using the standard inspection protocol, which includes optical enhancement where necessary
- a sample size for ginger rhizomes of 600 units (single ginger rhizome pieces) is inspected from each consignment. If a consignment has less than 1000 units, then 450 units are to be inspected. For consignments of less than 450 units, all units must be inspected
- if no live quarantine pests, disease symptoms or other regulated articles are detected in the inspection lot, the consignment will be released from quarantine
- consignments will fail if quarantine pests and/or regulated articles are detected during on-arrival inspections. Remedial action is to be taken when this occurs
- if product continually fails inspection, the export program may be suspended and audited, with reinstatement after DAFF Biosecurity is satisfied that appropriate corrective action has been taken.

5.2 Uncategorised pests

If an organism that has not been categorised is detected on fresh ginger during inspection, it will require assessment by DAFF Biosecurity to determine its quarantine status and if phytosanitary action is required. The detection of any pests of quarantine concern not already identified in the analysis may result in remedial action, as appropriate.

Ants are frequently intercepted with the importation of fresh produce from Fiji. While ants are not typically considered pests of ginger or associated with ginger rhizomes, they may nevertheless be on the importation pathway as contaminants and be detected during quarantine inspection.

Table 5.1 lists the ants most likely to be intercepted on fresh ginger from Fiji, and their quarantine status.

Table 5.1 Ant species in Fiji that may be intercepted in fresh ginger imports

Ant species	Pest status	Presence in Australia	Actionable?
Camponotus chloroticus Emery 1897 [Formicidae] Carpenter ant	Not a pest of ginger, but a potential contaminant.	No records found. Not known to be present in Australia (Shattuck 2000).	**Yes**
Paratrechina vaga (Forel 1901) [Formicidae] Forest parrot ant	Not a pest of ginger, but a potential contaminant. The pest status of *Paratrechina vaga* stems from its habit of inhabiting structures and agricultural fields (Tenbrink and Hara 1992).	Yes – Present in Australia (Taylor *et al*. 2000).	No
Pheidole fervens Smith, F. 1858 [Formicidae] Ant	Not a pest of ginger, but a potential contaminant. There have been 64 interceptions of *Pheidole fervens* in New Zealand, 69 % of which came from Fiji (Stanley *et al*. 2007a).	No – Only two species of Fijian *Pheidole* (*P. megacephala* and *P. oceanica*) are present in Australia. *Pheidole fervens* is **NOT** present in Australia.	**Yes**
Pheidole megacephala (Fabricius [Formicidae] Madeira ant	Not a pest of ginger, but a potential contaminant. Intercepted in New Zealand on fresh ginger imported from Fiji.	Yes – Present in NSW, NT, Qld, Vic. and WA (AICN 2011).	No
Tetramorium bicarinatum (Nylander 1846) [Formicidae] Guinea ant	Not a pest of ginger, but a potential contaminant. Intercepted in New Zealand on fresh ginger imported from Fiji.	Yes – Present in Australia (Taylor *et al*. 2000). Recorded in NT, Qld, Vic. and WA (APPD 2011).	No
Tetramorium simillimum (Smith, F. 1851) [Formicidae] Tetramorium ant	Not a pest of ginger, but a potential contaminant. This species has been intercepted in New Zealand on fresh ginger from Fiji in air cargo (Stanley *et al*. 2007b).	Yes – Present in Australia (Taylor *et al*. 2000). Recorded in NT, Qld and WA (APPD 2011).	No

5.3 Review of policy

DAFF Biosecurity may review the import policy after the first year of trade.

Australia reserves the right to review and amend the import policy if circumstances change. Australia is prepared to review the policy after a substantial volume of trade has occurred.

6 Conclusion

The findings of this draft IRA report are based on a comprehensive analysis of relevant scientific literature. DAFF Biosecurity considers that the risk management measures and operational system for the maintenance and verification of phytosanitary status proposed in this draft IRA report will provide an appropriate level of protection against the pests identified in this risk analysis.

Appendices

Appendix A Initiation and categorisation for pests of fresh ginger from Fiji

Initiation (columns 1-3) identifies the pests of fresh ginger that have the potential to be on fresh ginger rhizomes produced in Fiji using commercial production and packing procedures.

Pest categorisation (columns 4-7) identifies which of the pests with the potential to be on fresh ginger are quarantine pests for Australia and require pest risk assessment.

The steps in the initiation and categorisation processes are considered sequentially, with the assessment terminating at the first ‘No’ for columns 3, 5 or 6 or ‘Yes’ for column 4.

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

Contaminating pests are not considered under categorisation. Contaminant pests are addressed under existing standard operational procedures.

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
ARTHROPODA: Insecta						
Coleoptera (beetles)						
Adoretus versutus Harold, 1869 [Scarabaeidae] Rose beetle	Yes (Evenhuis 2007; Stout 1982).	No – Adults feed on ginger leaves (Stout 1982; Waterhouse and Norris 1987). Eggs may be present in the soil, and larvae may feed on roots of some host plants (Waterhouse and Norris 1987), but association with ginger rhizomes is not reported.	No records found.			No
Elytroteinus subtruncatus (Fairmaire, 1881) [Curculionidae] Fiji ginger weevil	Yes (Evenhuis 2007; Stout 1982).	Yes – Weevil larvae bore in the stems and rhizomes of ginger (Stout 1982). It has been detected in New Zealand during quarantine inspection of imported ginger from Fiji (NZ interception data).	No records found.	Yes. Hosts such as avocado, lemon and sugarcane (Mau and Martin Kessing 1992a) are locally common.	Yes. Feeding of the larvae results in wilting and loss of vigour in host plants. If feeding is extensive, the host may die (Mau and Martin Kessing 1992a).	**Yes**
Lasioderma serricorne (Fabricius, 1792) [Anobiidae] Cigarette beetle	Yes (Evenhuis 2007).	Yes – The cigarette beetle is a pest of stored plant products including spices (Cabrera 2008; Devasahayam and Abdulla Koya 2005) and has been intercepted on ginger in New Zealand.	Yes – Recorded in ACT, NSW, NT, Qld, SA, Tas., Vic. and WA (AICN 2011).			No

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Diptera (true flies; mosquitoes)						
Atherigona orientalis (Schiner, 1868) [syn: *Atherigona excisa* Thomson 1869] [Muscidae] Pepper fruit fly	Yes (Evenhuis 2007).	No – This species is typically associated with rotting or damaged plant material, although has been reported to attack sound melons (Pont 1991). Maggots of five diptera species, including *Atherigona orientalis,* were extracted from ginger root in Hawaii in 1937. *Eumerus marginatus* was the most abundant species reported in this sample (Hawaiian Entomological Society 1939), and the *Atherigona orientalis* larvae may have only been secondary saprophagous feeders.	Yes – Present in NSW, Qld and WA (Pont 1991).			No
Exaireta spinigera (Wiedemann, 1830) [Stratiomyidae] Garden Soldier Fly	Not known to be present in Fiji. However, it has been detected on ginger from Fiji during quarantine inspection in New Zealand on at least one occasion (NZ interception data).	No – Larvae live in damp soil or decaying organic material and feed on rotting vegetation (Hadlington and Johnston 1998; Swann *et al*. 2006).	Yes – Present in Australia (Bickel and Elliot 2005). Recorded in NSW, Vic. and Tas. (AICN 2011), Qld and WA (APPD 2011).			No
Limonia strigivena (Walker, 1861) [syn: *Libnobia strigivena*] [Tipulidae] Crane fly	Yes (Stout 1982; Evenhuis 2005).	No – Larvae have been recorded in rotting ginger rhizomes (Stout 1982), but are unlikely to be on the pathway.	Yes (Bugledich *et al*. 1999).			No
Hemiptera (aphids; leafhoppers; mealybugs; psyllids; scales; true bugs; whiteflies)						
Aspidiella hartii (Cockerell, 1895) [syn: *Aspidiotus hartii* Cockerell, 1895] [Diaspididae] Yam scale	Yes (Stout 1982; Wilson and Evenhuis 2007).	Yes – This scale may be found on ginger rhizomes (Anandaraj *et al*. 2001; Stout 1982). It is known to be a storage pest of ginger (Devasahayam and Abdulla Koya 2005).	There are unconfirmed records of this species in the Northern Territory (NTDPIF 2001).	Yes. Some host plants are present in Australia (Ben-Dov *et al*. 2011; Williams and Watson 1988), although they are neither widespread nor common. First-stage larvae are active crawlers, and are capable of seeking out suitable hosts (Mau and Martin Kessing 1992b).	Yes. Hosts include some minor crop species including taro, sweet potato, turmeric, yam and ginger (Ben-Dov *et al*. 2011; Williams and Watson 1988).	**Yes**

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Aspidiella sacchari (Cockerell, 1893) [Diaspididae] Sugarcane scale	Yes (Wilson and Evenhuis 2007).	No – Ginger is not reported as a host (Hodgson and Lagowska 2011; Ben-Dov *et al*. 2011). The Pacific Islands Pest Database lists *Aspidiella sacchari* as a pest of ginger, citing Hinckley (1965) as the source. However, this appears to be an error, as there are no reports of *Aspidiella sacchari* (or its synonyms) on ginger in the original reference (Hinckley 1965).	There are unconfirmed records of this species reported from Qld (APPD 2011).			No
Aspidiotus destructor Signoret, 1869 [Diaspididae] Coconut scale	Yes (Stout 1982; Wilson and Evenhuis 2007).	Yes – Found on the stem and rhizomes of ginger if they are exposed at the soil surface (Stout 1982).	Yes – Recorded in NSW, NT, Qld, Vic. and WA (Ben-Dov *et al.* 2011; AICN 2011; Donaldson and Houston 2002).			No
Dysmicoccus brevipes (Cockerell, 1893) [Pseudococcidae] Pineapple mealybug	Yes (Wilson and Evenhuis 2007; Ben-Dov *et al*. 2011).	Yes – Ginger is a host of *Dysmicoccus brevipes*, which infests the roots, leaves and natural cavities of the host plant (Ben-Dov *et al*. 2011).	Yes – Recorded in NSW, NT, Qld and WA (Ben-Dov *et al.* 2011; AICN 2011).			No
Hemiberlesia palmae (Cockerell, 1893) [Diaspididae] Tropical palm scale	Yes (Wilson and Evenhuis 2007).	No – Ginger is a host, but it is likely to only be found on the leaves (Ben-Dov *et al*. 2011). Not likely to be present on rhizomes.	Yes – Recorded in Qld (AICN 2011). Present in Australia (Ben-Dov *et al.* 2011).			No
Icerya seychellarum seychellarum (Westwood, 1855) [Monophlebidae] Seychelles scale	Yes (Williams and Watson 1990).	No – Found on the leaves of host plants, where it deposits honeydew (Williams and Watson 1990). Not likely to be present on rhizomes.	Yes – Recorded in NT and Qld (AICN 2011; Ben-Dov *et al.* 2011).			No
Parasaissetia nigra (Nietner, 1861) [Coccidae] Nigra scale	Yes (Stout 1982; Wilson and Evenhuis 2007).	No – Found on the stems of ginger plants (Stout 1982). Not likely to be present on rhizomes.	Yes – Recorded in NSW, NT, Qld, Vic. and WA (AICN 2011).			No

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Planococcus minor (Maskell, 1897) [syn: *Planococcus pacificus* Cox, 1981] [Pseudococcidae] Pacific mealybug	Yes (Wilson and Evenhuis 2007; Ben-Dov *et al.* 2011).	No – Usually found on the stems of host plants, and occasionally the leaves (Watson 2011). Not likely to be present on rhizomes.	Yes – Recorded in ACT, NSW, NT, Qld and SA (AICN 2011).			No
Pinnaspis strachani (Cooley, 1899) [Diaspididae] Hibiscus snow scale	Yes (Wilson and Evenhuis 2007).	No – Ginger is a host (Ben-Dov *et al.* 2011) but this scale is not likely to be present on rhizomes. *Pinnaspis strachani* attacks the leaves, stems and fruit of host plants (Tenbrick *et al*. 2007).	Yes – Recorded in SA (Ben-Dov *et al*. 2011).			No
Selenaspidus articulatus (Morgan, 1889) [Diaspididae] Rufous scale	Yes (Williams and Watson 1988; Wilson and Evenhuis 2007).	No – Attacks the leaves (especially the upper surfaces) and sometimes found on the fruits/pods, growing points and stems of hosts (Watson 2011). Not likely to be present on rhizomes.	Yes – This species is present in Australia (Ben-Dov *et al*. 2011).			No
Lepidoptera (butterflies; moths)						
Agrotis ipsilon (Hufnagel, 1766) [Noctuidae] Black cutworm	Yes (Evenhuis 2007).	No – Larvae feed on seedling shoots at night, sheltering in the soil during the day (CABI 2011). Not likely to be present on the rhizomes.	Yes – Present in NSW, Qld, Vic., Tas. and WA (AICN 2011).			No
Opogona regressa Meyrick, 1916 [Tineidae]	Yes (Stout 1982; Evenhuis 2007).	Yes – The larvae of several *Opogona* species attack stored tubers and occasionally feed on living plant material adjacent to decaying material (Robinson and Tuck 1997).	No records found.	Yes. Little is known about the biology of this species, or its preferred hosts. Mariau (2001) reports the larvae feed on dead stems and leaves of coconut and oil palms. Other species of *Opogona* present in Australia feed on pawpaw bark, banana flowers, gladioli corms and *Ganoderma* (Robinson and Tuck 1997).	No. *Opogona regressa* is a saprophagous species and not of any economic importance (Veitch and Greenwood 1921; Maddison and Crosby 2009).Not considered to be of quarantine importance (Stout 1982). The larvae of *Opogona* species are detritophagous, feeding typically on dead or dying plant material (Robinson and Tuck 1997).	No

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Piletocera xanthosoma Meyrick, 1886 [Crambidae]	Yes (Stout 1982).	Yes – The larvae of this species feed on the outer rhizome tissue of ginger (Stout 1982), although Hinckley (1964) reports that they bore deeply into the rhizomes under moist conditions. Large amounts of yellow frass are produced by feeding (Hinckley 1964), so most affected rhizomes would be removed during harvesting or processing.	No records found.	Little is known about the biology of this species, or its preferred hosts. It is unclear whether larvae could locate a suitable host and complete development if released into the Australian environment.	No. While larvae of this moth were intercepted once in the US and Canada on ginger exported from Fiji in 1962 (Hinckley 1964), there are no other reports of this species as a pest. It was not considered to be an economic pest by Hinckley (1964). Reports in the literature are scarce, indicating that *Piletocera xanthosoma* is not recognised as a pest in countries where it is present.	No
NEMATODA: Secernetea						
Tylenchida						
Aphelenchoides bicaudatus (Imamura, 1931) [Aphelenchoididae] Nematode	Yes (Orton Williams 1980).	Yes – *Aphelenchoides bicaudatus* is commonly found in the rhizosphere of many plants (UNL Nematology 2008). May be present on the surface of poorly cleaned rhizomes.	Yes – Recorded in NSW, Qld, Vic. and WA (Khair 1986; McLeod *et al*. 1994).			No
Caloosia longicaudata (Loos, 1948) Siddiqi & Goodey, 1964 [Caloosiidae] Nematode	Yes (Orton Williams 1980).	Yes – *Caloosia* species are ecto-parasitic feeders on roots (Bridge *et al*. 1990). May be present on the surface of poorly cleaned rhizomes.	No records found.	Yes. Another *Caloosia* species, *Caloosia nudata*, has been recorded in Australia (McLeod *et al.* 1994). Other species are associated with roots of rice, coffee and cloves elsewhere (Luc *et al*. 1990).	No. Not reported to cause economic damage. Not listed as a damaging nematode by Luc *et al.* (1990) or Bridge (1988).	No
Discocriconemella discolabia (Diab & Jenkins, 1966) De Grisse, 1967 [Criconematidae] Ring nematode	Yes (Orton Williams 1980).	Yes – Ring nematodes are exclusively root parasitic, and feed on the root cortex of the ginger plant, with the anterior of the body thrust into the tissue (Siddiqi 2000). May be present on the surface of poorly cleaned rhizomes.	No records found.	Yes. *Discocriconemella discolabia* is polyphagous and has been recorded on more than 20 plant hosts (Orton Williams 1980), many of which are present in Australia.	Yes. Ring nematodes can be a nuisance on certain crops when large populations build up (Siddiqi 2000). Commercial crop hosts include cabbage, pawpaw and *Citrus* spp. (Orton Williams 1980).	**Yes**

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Helicotylenchus dihystera (Cobb, 1893) Sher, 1961 [Hoplolaimidae] Spiral nematode	Yes (Orton Williams 1980).	Yes – *Helicotylenchus* species may be found in the root cortex of host plants, but migration through the tissues has not been reported (Luc *et al.* 1990). May be present on the surface of poorly cleaned rhizomes.	Yes – Recorded in NSW, NT, Qld, SA and Vic. (McLeod *et al*. 1994; Khair 1986; Sauer 1981).			No
Helicotylenchus egyptiensis Tarjan, 1964 [Hoplolaimidae] Spiral nematode	Yes (Orton Williams 1980).	Yes – *Helicotylenchus* species may be found in the root cortex of host plants, but migration through the tissues has not been reported (Luc *et al.* 1990). May be present on the surface of poorly cleaned rhizomes.	No records found.	Yes. *Helicotylenchus* spp. are known to be amphimictic and mitotically parthenogenic (Evans 1998), so could establish without a mate. Host plants such as sugarcane, lemon and orange (Zeidan and Geraert 1990) are present in Australia	Yes. Commercial host species include onion, cabbage, lemon, orange, carrot, barley, rice, sugarcane and potato (Kazi 1996; Orton Williams 1980; Zeidan and Geraert 1990; Bridge *et al*. 2005).	**Yes**
Helicotylenchus erythrinae (Zimmerman, 1904) Golden, 1956 [Hoplolaimidae] Spiral nematode	Yes (Kirby *et al*. 1980).	Yes – *Helicotylenchus* species may be found in the root cortex of host plants, but migration through the tissues has not been reported (Luc *et al.* 1990). May be present on the surface of poorly cleaned rhizomes.	Yes – Recorded in Qld and SA (McLeod *et al.* 1994; Khair 1986).			No
Helicotylenchus indicus Siddiqi, 1963 [Hoplolaimidae] Spiral nematode	Yes (Orton Williams 1980).	Yes – *Helicotylenchus* species may be found in the root cortex of host plants, but migration through the tissues has not been reported (Luc *et al.* 1990). May be present on the surface of poorly cleaned rhizomes.	No records found.	Yes. *Helicotylenchus* spp. are known to be amphimictic and mitotically parthenogenic (Evans 1998), so could establish without a mate.	Yes. Affects a number of commercially grown plant species including chilli, pawpaw, citrus, coconut, taro, mango, banana, rice, eggplant, sorghum and maize (Kazi 1996; Van den Berg and Kirby 1979; Orton Williams 1980; Bridge *et al*. 2005).	**Yes**
Helicotylenchus mucronatus Siddiqi, 1964 [Hoplolaimidae] Spiral nematode	Yes (Orton Williams 1980).	Yes – *Helicotylenchus* species may be found in the root cortex of host plants, but migration through the tissues has not been reported (Luc *et al.* 1990). May be present on the surface of poorly cleaned rhizomes.	No records found.	Yes. *Helicotylenchus* spp. are known to be amphimictic and mitotically parthenogenic (Evans 1998), so could establish without a mate. *Helicotylenchus mucronatus* has an extensive host list (Orton Williams 1980), many of which are present in Australia.	Yes. Reported as a root parasite of banana, yams, taro and sweet potato by Bridge (1988) and Luc *et al*. (1990). Responsible for root necrosis and stunted growth of bananas, and leaf chlorosis and severe cortical root necrosis of sweet potato roots and tubers in the Pacific (Bridge 1988).	**Yes**

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Hemicriconemoides cocophillus (Loos, 1949) Chitwood & Birchfield, 1957) [Criconematidae] Ring nematode	Yes (Orton Williams 1980).	Yes – This species was reported on ginger in Fiji in an unpublished survey. *Hemicriconemoides cocophillus* is a common nematode attacking the roots of more than 50 plant hosts (Orton Williams 1980). May be present on the surface of poorly cleaned rhizomes.	Yes – Recorded in NT, Qld and WA (Khair 1986; McLeod *et al.* 1994).			No
Hoplolaimus seinhorsti Luc, 1958 [Hoplolaimidae] Lance nematode	Yes (Orton Williams 1980).	Yes – This species is typically ectoparasitic, but can feed as an endoparasite on cortical cells by migrating inside the root tissue of hosts (CABI 2011).	Yes – Recorded in NT, Qld and WA (McLeod *et al*. 1994; Sauer 1981).			No
Meloidogyne arenaria (Neal, 1889) Chitwood, 1949 [Heteroderidae] Root-knot nematode	Yes (Orton Williams 1980).	Yes – Juvenile *Meloidogyne* species invade host roots to feed and complete development (Luc *et al.* 1990).	Yes – Recorded in NSW, Qld, SA, Tas., Vic. and WA (Khair 1986; McLeod *et al.* 1994).			No
Meloidogyne incognita (Kofoid & White, 1919) Chitwood, 1949 [Heteroderidae] Root-knot nematode	Yes (Stout 1982; Orton Williams 1980).	Yes – Ginger rhizomes may be infested (Pegg *et al*. 1974).	Yes – Recorded in NSW, NT, Qld, SA, Tas., Vic. and WA (Khair 1986; McLeod *et al.* 1994).			No
Meloidogyne javanica (Treub, 1885) Chitwood, 1949 [Heteroderidae] Root-knot nematode	Yes (Orton Williams 1980).	Yes – Ginger rhizomes may be infested (Pegg *et al*. 1974).	Yes – Recorded in NSW, NT, Qld, SA, Tas., Vic. and WA (Khair 1986; McLeod *et al*. Sauer 1981)			No
Mesocriconema denoudeni de Grisse, 1967 [syn: *Macroposthonia denoudeni* de Grisse 1967; *Criconemella denoudeni* (de Grisse 1967) Luc & Raski 1981] [Criconematidae] Ring nematode	Yes (Orton Williams 1980).	Yes – *Mesocriconema* species are migratory ectoparasites that feed on the roots of host plants (Siddiqi 2000). May be present on the surface of poorly cleaned rhizomes.	No records found.	Yes – This nematode is polyphagous and has been recorded on more than 65 plant hosts (Orton Williams 1980), many of which are present in Australia.	Yes – Ring nematodes can be a nuisance on certain crops when large populations build up (Siddiqi 2000). Not listed as a major pest in Luc *et al*. (1990) or Bridge (1988), but hosts include a number of commercial crop species (Orton Williams 1980).	**Yes**

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Mesocriconema onoense (Luc, 1959) Loof & De Grisse, 1989 [syn: *Macroposthonia onoense* (Luc, 1959) de Grisse & Loof, 1965; *Criconemella onoensis* (Luc, 1959) Luc & Raski, 1981] [Criconematidae] Ring nematode	Yes (Orton Williams 1980).	Yes – *Mesocriconema* species are migratory ectoparasites that feed on the outside of the host plant (Siddiqi 2000). May be present on the surface of poorly cleaned rhizomes.	Yes – Recorded in NT and Qld (Khair 1986; McLeod *et al*. 1994).			No
Pratylenchus coffeae (Zimmerman, 1898) Filipjev & Schuurmans Stekhoven, 1941 [Pratylenchidae] Root lesion nematode	Yes (Orton Williams 1980).	Yes – All life stages of *Pratylenchus* species may be found in the root cortex (Luc *et al.* 1990).	Yes – Recorded in NSW, Qld, SA, Vic. and WA (Khair 1986; McLeod *et al*. 1994).			No
Radopholus similis (Cobb, 1893) Thorne 1949 [Pratylenchidae]	Yes (Orton Williams 1980).	Yes – Ginger is a host of *Radopholus similis* (CABI 2011). *Radopholus* species are endoparasites of root and corm/tuber tissues (Luc *et al.* 1990).	Yes – Recorded in NSW, NT, Qld, SA and WA (Khair 1986; Sauer 1981; McLeod *et al*. 1994).			No
Rotylenchulus reniformis Lindford & Oliveira 1940 [Hoplolaimidae]	Yes (Orton Williams 1980).	Yes – *Rotylenchulus* species are sedentary semi-endoparasites that feed on the roots (Luc *et al.* 1990).	Yes – Recorded in NT, Qld and WA (Khair 1986; McLeod *et al.* 1994; Sauer 1981).			No
Sphaeronema sp. [Tylenchulidae] Cystoid nematode	Yes (Smith *et al*. 2007; Orton Williams 1980).	Yes – Unidentified *Sphaeronema* nematodes have been detected in ginger seed in Fiji (Smith *et al.* 2007).	An unidentified *Sphaeronema* species has been recorded on prickly pear in Queensland (McLeod *et al*. 1994).	Yes – The *Sphaeronema* sp. (or spp.) found in Pacific surveys has not been described, so information on its ability to establish and spread is unavailable. However, it has been reported on plant hosts from more than 20 genera (Orton Williams 1980). At least one *Sphaeronema* species is already present in Queensland (McLeod *et al*. 1994). Parts of Australia would be climatically suitable for establishment.	Yes – A *Sphaeronema* species has been reported attacking a number of important host crops in the Pacific, including pineapple, banana, coconut, papaya and pumpkin (Orton Williams 1980), although the degree of damage is not reported. Some *Sphaeronema* species are known to have pathogenic effects on a range of plant species, and can kill host trees (Hennon *et al.* 1986; Eisenback and Hartman 1985).	**Yes**

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Xiphinema krugi Lordello, 1955 [Longidoridae]	Yes (Orton Williams 1980).	Yes – *Xiphinema* species feed on the meristematic tissue near the root tips (Luc *et al.* 1990). May be present on the surface of poorly cleaned rhizomes.	Yes – Recorded in NSW (Khair 1986; McLeod *et al.* 1994).			No
BACTERIA						
Betaproteobacteria						
Burkholderiales (Ralstonia)						
Ralstonia solanacearum (Smith 1896) Yabuuchi *et al*. 1995 Bacterial wilt	Not reported to be present in Fiji (Dingley *et al*. 1981; Stout 1982; Smith *et al.* 2007).	No – The bacterial wilt strain affecting ginger is not known to be present in Fiji.	No – Bacterial wilt ginger biotype (IV) was introduced to south-eastern Queensland in 1965, initially causing heavy losses (Pegg *et al*. 1974). Subsequently controlled and no longer believed to be present in Australia.			No
Enterobacteriales (Erwinia, Klebsiella)						
Erwinia carotovora subsp. *carotovora* (Jones, 1901) Bergey *et al*. 1923 Soft rot	Yes (Dingley *et al.* 1981).	Yes – Causes rot in rhizomes and results in serious losses of stored ginger (Pegg *et al*. 1974).	Yes – Present in Australia (Pegg *et al*. 1974).			No
Dickeya sp. [syn: *Erwinia chrysanthemi* (Burkh.) Young *et al*., 1978] Bacterial soft rot	Not confirmed, but suspected of being present.	Yes – Causes postharvest rotting of rhizomes (Stirling 2002).	Yes – Responsible for soft rot of ginger in Qld (Stirling 2002).			No
CHROMALVEOLATA						
Peronosporales (Albugo, Phytophthora)						
Globisporangium splendens (Hans Braun) Uzuhashi, Tojo & Kakish. [syn: *Pythium splendens* Hans Braun] Root rot	Yes (Firman 1972).	Yes – Reported on ginger in Malaysia (Farr and Rossman 2011).	Yes – Reported in Qld (Simmonds 1966), Tas. (Sampson and Walker 1982) and WA (Shivas 1989).			No

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pythium aphanidermatum (Edson) Fitzp. Soft rot	Yes. Reported in an unpublished survey (McKenzie *et al.* 2004).	Yes – Young sprouts are susceptible, with rot spreading to the rhizome (Anandaraj *et al.* 2001; Dohroo 2005).	Yes – Present in NSW (Letham 1995), Qld (Simmonds 1966), SA (Cook and Dube 1989) and WA (Shivas 1989).			No
Pythium diclinum Tokun. [syn: *Pythium gracile* Schenk] Soft rot	Yes (Dingley *et al*. 1981; Firman 1972).	Yes – This pathogen affects ginger rhizomes (Dohroo 2005).	Yes – Present in WA (Shivas 1989). Recorded in NSW and WA (APPD 2011).			No
Pythium graminicola Subram.	Yes (Lomavatu *et al*. 2009).	Yes – This pathogen has been isolated from ginger rhizomes in Fiji (Lomavatu *et al*. 2009).	Yes – Recorded in Qld (Croft 1987) and SA (Cook and Dube 1989).			No
Pythium myriotylum Drechsler Soft rot	Yes (Stirling *et al*. 2009).	Yes – Young sprouts are susceptible, with rot spreading to the rhizome (Anandaraj *et al.* 2001; Meena and Mathur 2003).	Yes – Present in NSW (Stovold 1973; Letham 1995), Qld (Simmonds 1966; Stirling *et al*. 2009) and WA (Shivas 1989).			No
Pythium vexans de Bary Root rot	Yes (Firman 1972; Lomavatu *et al*. 2009).	Yes – This pathogen has been isolated from ginger rhizomes in Fiji (Lomavatu *et al*. 2009).	Yes – Recorded in NSW (Letham 1995), Qld (Simmonds 1966), SA (Cook and Dube 1989) and WA (Shivas 1989).			No
FUNGI						
Armillaria mellea (Vahl : Fr.) P. Kumm. [Anamorph: *Rhizomorpha subcorticalis* Pers. ex Gray] Rhizome rot	Yes (Dingley *et al.* 1981).	No – Ginger was reported as a host in Australia (Simmonds 1966), but this is likely to have been a misidentification. Ginger is not known as a host of *Armillaria mellea*. While *Armillaria mellea* is a root pathogen, it is typically associated with hardwood trees and conifer hosts, as well as decaying wood. Unlikely to be on fresh ginger.	No. Older Australian records (e.g. Simmonds 1966) are likely to be misidentifications.			No
Cochliobolus geniculatus R.R. Nelson [Anamorph: *Curvularia geniculata* (Tracy & Earle) Boedijn] Seedling blight	Yes (Firman 1972; Dingley *et al*. 1981).	Yes – Association with ginger reported in Hong Kong (Farr and Rossman 2011).	Yes – Reported in Australia (Sivanesan 1987; Hyde and Alcorn 1993).			No

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. [Teleomorph: *Glomerella cingulata* (Stoneman) Spauld. & H. Shrenk] Rhizome rot	Yes (Dingley *et al*. 1981) [as *Glomerella cingulata*, but refers to the conidial stage being found].	Yes – This fungus causes rhizome rot of ginger (Stout 1982).	Yes – Recorded in NSW (Letham 1995), Qld (Simmonds 1966), SA (Cook and Dube 1989), Tas. (Sampson and Walker 1982), Vic. (Cunnington 2003) and WA (Shivas 1989).			No
Colletotrichum truncatum (Schwein.) Andrus & W.D. Moore [syn: *Colletotrichum capsici* (Syd.) E.J. Butler & Bisby] Blight	Yes (Firman 1972).	Yes – Reported to cause stem rots. Recorded on ginger in China, India and Brunei Darussalam (Farr and Rossman 2011).	Yes – Recorded in NSW (Letham 1995) and WA (Shivas 1989).			No
Fusarium oxysporum f.sp. *zingiberi* E.E. Trujillo Fusarium yellows	Yes (Weiss 2002).	Yes – Present in the ginger rhizome (Pappalardo *et al*. 2009).	Yes – Widely distributed in Australia (Weiss 2002; Pappalardo *et al*. 2009).			No
Gibberella baccata (Wallr.) Sacc. [Anamorph: *Fusarium lateritium* Nees:Fr.] Rhizome rot	Yes (Dingley *et al*. 1981).	Yes – This fungus causes rhizome rot of ginger (Dingley *et al*. 1981).	Yes – Recorded in NSW, Qld and SA (APPD 2011).			No
Gibberella subglutinans (E. Edwards) P.E. Nelson, Toussoun & Marasas [syn: *Gibberella fujikuroi* var. *subglutinans* E.T. Edwards] [Anamorph: *Fusarium subglutinans* (Wollenw. & Reinking) P.E. Nelson, Toussoun & Marasas] Rhizome rot	Yes (Dingley *et al*. 1981; Stout 1982) [as *Gibberella fujikuroi* var. *subglutinans*].	Yes – This fungus causes rhizome rot of ginger (Stout 1982).	Yes – Recorded in NSW (Letham 1995) and Qld (APPD 2011) [as *Gibberella fujikuroi* var. *subglutinans*].			No
Haematonectria haematococca (Berk. & Broome) Samuels & Rossman [syn: *Nectria haematococca* Berk. & Broome] [Anamorph: *Fusarium solani* (Mart.) Sacc.] Root rot	Yes (Dingley *et al*. 1981; Stout 1982).	Yes – This fungus causes rhizome rot of ginger (Meena and Mathur 2003).	Yes – Recorded in Qld (Simmonds 1966), SA (Cook and Dube 1989), Tas. (Sampson and Walker 1982) and WA (Shivas 1989). Anamorph present in NSW (Letham 1995).			No

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Macrophomina phaseolina (Tassi) Goid. Damping off	Yes (Firman 1972)	Yes – Affects stems and roots of hosts, and present in soil. Reported on ginger in India (Farr and Rossman 2011).	Yes – Reported in NSW (Letham 1995), SA (Cook and Dube 1989) and WA (Shivas 1989).			No
Memnoniella echinata (Rivolta) Galloway [syn: *Stachybotrys echinata* (Rivolta) G. Sm.] Black rot	Yes. Reported in an unpublished survey (McKenzie *et al.* 2004).	Yes – This fungus causes a storage rot in ginger (Srivastava *et al*. 1998).	Yes – Recorded in Qld (APPD 2011).			No
Boeremia exigua var. *exigua* (Desm.) Aveskamp, Gruyter & Verkley [syn: *Phoma exigua* var. *exigua* Desm.] Rhizome rot	Yes (Firman 1972) (as *Ascochyta phaseolorum* Sacc.)	Yes – A weak pathogen or wound parasite that can cause lesions and rotting of roots and rhizomes (CABI 2011).	Yes – Recorded in Qld (Simmonds 1966) (as *Ascochyta phaseolorum* Sacc.), Tas. (Sampson and Walker 1982) and WA (Shivas 1989) (as *Phoma exigua*).			No
Rhizoctonia solani J.G. Kühn (See *Thanatephorus cucumeris* (A.B. Frank) Donk)						
Rhizostilbella hibisci (Pat.) Seifert [Teleomorph: *Nectria mauritiicola (Henn.)* Seifert & Samuels] Rot	Yes. Reported in an unpublished survey (McKenzie *et al.* 2004).	No – This species is predominantly a saprophytic soil fungus. It is mildly parasitic on the roots and bark of host plants, and has been isolated with soil (Rossman *et al.* 1999 citing Siefert 1985). While this fungus infests soil, the soil would be removed from rhizomes prior to export. It attacks roots only under anaerobic or waterlogged conditions (Booth and Holliday 1998). Ginger is not a reported host of this species (Booth and Holliday 1998). An unpublished report by McKenzie *et al.* (2004) listed this species as occurring on ginger but with no further information. No herbaria specimens exist to support this record. No records of economic impacts on ginger were found supporting McKenzie *et al.* (2004).	No records found.			No

Pest	Present in Fiji	Potential to be on pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Sclerotium rolfsii Sacc. Stem rot	Yes (Dingley *et al*. 1981).	Yes – *Sclerotium rolfsii* causes a rhizome rot (Pegg *et al*. 1974; Stout 1982).	Yes – Recorded in Qld (Simmonds 1966; Vawdrey and Peterson 1990), SA (Cook and Dube 1989), Tas. (Sampson and Walker 1982) and WA (Shivas 1989).			No
Thanatephorus cucumeris (A.B. Frank) Donk [syn: *Corticium solani* (Prill. & Delacr.) Bourdot & Galzin [Anamorph: *Rhizoctonia solani* J.G. Kühn] Web blight	Yes (Dingley *et al*. 1981; Firman 1972 [as *Corticium solani*]).	Yes – This fungus has been reported on ginger rhizomes (Dohroo and Sharma 1992).	Yes – Recorded in NSW (Letham 1995), Qld (Simmonds 1966), SA (Cook and Dube 1989), Tas. (Sampson and Walker 1982) and WA (Shivas 1989).			No
Verticillium albo-atrum Reinke & Berthold Rhizome rot	Yes (Dingley *et al*. 1981).	Yes – Isolated from a rotted rhizome (Dingley *et al*. 1981).	Yes – Recorded in SA (Cook and Dube 1989), Tas. (Sampson and Walker 1982) and Vic. (Cunnington 2003), Other records from Qld, SA, Tas. and Vic. (APPD 2011).			No
VIRUSES						
Cucumber mosaic virus	Yes (Davis and Ruabete 2010). Reported in an unpublished survey (McKenzie *et al.* 2004).	Yes – Although not widely reported as a host of cucumber mosaic virus, this virus has been found in ginger in Fiji (Davis and Ruabete 2010). Virions are found in all parts of the host plant (Brunt *et al*. 2011), so would be carried in rhizomes.	Yes – Present in Australia (Büchen-Osmond *et al*. 1988). Recorded in NSW (Letham 1995), Qld (Simmonds 1966), SA (Cook and Dube 1989), Tas. (Sampson and Walker 1982) and WA (Jones *et al*. 2010).			No

Appendix B Additional quarantine pest data

Quarantine pest	***Elytroteinus subtruncatus* (Fairmaire, 1881)**
Synonyms	*Pteroporus subtruncatus* Fairmaîre, 1881
Common name(s)	Fiji ginger weevil, Fiji lemon weevil
Main hosts	*Colocasia esculenta* (Follett *et al*. 2007; Mau and Martin Kessing 1992a), *Hedychium coronarium*, *Strelitzia reginae*, *Cycas* spp., *Hemerocallis* sp., *Persea americana*, *Marattia douglasii*, *Citrus limon*, *Saccharum officinarum*, *Cordyline terminalis* (Mau and Martin Kessing 1992a; Follett *et al*. 2007), *Ipomoea batatas* (not confirmed) (Shea 2004), *Dioscorea* spp. (Wilson 1987), *Piper methysticum* (Fakalata 1981), *Begonia* spp. (Simmonds 1928; Simmonds 1932), *Zingiber officinale* (Engelberger and Foliaki 1992).
Distribution	Cook Islands, Fiji, Niue, Samoa, Tonga (CABI 2011), Hawaii, French Polynesia (Nishida 2008) Mau and Martin Kessing (1992a) recorded this species for New Zealand, apparently in error. The species is listed as a Regulated Pest for New Zealand, with interceptions subject to treatment, re-export or destruction (NZ MAF 2002). May (1993) does not consider it as being present in New Zealand. Miller (1923) recorded an interception on lemons entering New Zealand from Fiji.

Quarantine pest	***Aspidiella hartii* (Cockerell, 1895)**
Synonyms	*Aspidiotus hartii* Cockerell, 1895
Common name(s)	Yam scale
Main hosts	Has been reported on hosts from at least seven plant families. Known hosts include *Colocasia esculenta*, *Curcuma longa*, *Cyperus odoratus*, *Dioscorea alata*, *Ipomoea batatas*, *Portulaca oleracea*, *Tripsacum laxum*, *Zingiber officinale* (Ben-Dov *et al*. 2011).
Distribution	Dominican Republic, Federated States of Micronesia, Fiji, Guadeloupe, Haiti, India, Ivory Coast, Martinique, Mauritius, New Caledonia, Papua New Guinea, Philippines, Puerto Rico, Saint Croix, Sierra Leone, Solomon Islands, Tonga, Trinidad and Tobago, U.S. Virgin Islands, Vanuatu (Ben-Dov *et al*. 2011).

Quarantine pest	***Discocriconemella discolabia*** (Diab & Jenkins, 1966) De Grisse, 1967
Synonyms	*Criconemoides discolabia* Diab & Jenkins, 1966
Common name(s)	Ring nematode
Main hosts	*Brassica oleracea* var. *capitata* (cabbage), *Broussonetia papyrifera* (paper mulberry), *Calophyllum vitiense* (calophyllum), *Carica papaya* (pawpaw), *Ceiba pentandra* (kapok), *Citrus* spp., *Cordyline fruticosa* (Ti), *Cyathea* spp. (tree fern), *Dioscorea esculenta* (Asiatic yam), *Endospermum macrophyllum* (kauvula), *Garcinia myrtifolia* (garcinia), *Ipomoea batatas* (sweet potato), *Pandanus* sp. (screw-pine), *Pinus caribaea* (Caribbean pine), *Piper aduncum* (spiked pepper), *Piper methysticum* (kava), *Theobroma cacao* (cocoa), *Xanthosoma sagittifolium* (yautia) (Orton Williams 1980).
Distribution	Fiji, Tonga, Papua New Guinea (Bridge 1988).

Quarantine pest	***Mesocriconema denoudeni*** (De Grisse, 1967) Loof & De Grisse, 1989
Synonyms	*Macroposthonia denoudeni* De Grisse, 1967 *Criconemella denoudeni* (De Grisse, 1967) Luc & Raski, 1981 *Criconemoides denoudeni* (De Grisse, 1967) Luc, 1970 *Mesocriconema denoudeni* (DeGrisse) Loof & De Grisse, 1989
Common name(s)	Ring nematode
Main hosts	*Abelmoschus esculentus* (okra), *Adenanthera pavonine* (red-bead tree), *Alocasia macrorrhiza* (giant taro), *Ananas comosus* (pineapple), *Arachis hypogaea* (groundnut), *Artocarpus altilis* (breadfruit), *Arundo donax* (giant reed), *Brassica oleracea* var. *capitata* (cabbage), *Brassica rapa* subsp. *chinensis* (Chinese cabbage), *Brassica rapa* subsp. *pekinensis* (Pe-tsai), *Calopogonium mucunoides* (calopo), *Camellia sinensis* (tea), *Capsicum annuum* (bell pepper), *Capsicum frutescens* (chilli), *Carica papaya* (pawpaw), *Casuarina equisetifolia* (Casuarina), *Cinnamomum* sp., *Citrullus lanatus* (watermelon), *Citrus aurantifolia* (Key lime), *Citrus limon* (lemon), *Coffea* sp., *Colocasia esculenta* (taro), *Cucumis sativus* (cucumber), *Cuphea carthagenensis* (Colombian waxweed), *Cyathea* spp. (tree fern), *Cyperus aromaticus* (navua sedge), *Cyrtosperma merkusii* (giant swamp taro), *Dioscorea alata* (white yam), *Dioscorea esculenta* (Asiatic yam), *Endospermum macrophyllum* (kauvula), *Erythrina* sp. (coral tree), *Eucalyptus deglupta* (kamarere), *Euodia hortensis*, *Fagraea berteriana* (perfume flower tree), *Hedychium coronarium* (butterfly ginger), *Hibiscus manihot* (hibiscus root), *Inocarpus fagiferus* (Tahitian chestnut), *Lactuca sativa* var. *capitata* (head lettuce), *Leucaena leucocephala* (leucaena), *Lycopersicon esculentum* (tomato), *Mangifera indica* (mango), *Manihot esculenta* (cassava), *Miscanthus floridulus* (Japanese silvergrass), *Monochoria vaginalis* (pickerel weed), *Musa sapientum* (sweet banana), *Neolamarckia cadamba* (common bur-flower tree), *Nicotiana tabacum* (tobacco), *Pandanus* sp. (screw-pine), *Persea americana* (avocado), *Phaseolus vulgaris* (common bean), *Pinus caribaea* (Caribbean pine), *Pinus massoniana* (masson pine), *Piper methysticum* (kava), *Psidium guajava* (guava), *Saccharum edule* (darooka), *Saccharum officinarum* (sugarcane), *Solanum melongena* (aubergine, eggplant), *Sorghum bicolor* (sorghum), *Spathodea campanulate* (African tulip tree), *Swietenia macrophylla* (big leaved mahogany), *Tectona grandis* (teak), *Theobroma cacao* (cocoa), *Xanthosoma sagittifolium* (yautia), *Zea mays* (maize), *Zingiber officinale* (ginger) (Orton Williams 1980; Grandison 1996; Kirby *et al*. 1980).
Distribution	Fiji (Orton Williams 1980), American Samoa (Grandison 1996), Thailand (Pholcharoen *et al*. 1972), USA (Wehunt *et al*. 1991).

Quarantine pest	***Helicotylenchus egyptiensis*** Tarjan, 1964
Synonyms	*Rotylenchoides egyptiensis* Whitehead, 1958
Common name(s)	Spiral nematode
Main hosts	*Allium cepa* (onion), *Avena sativa* (oat), *Brassica oleracea* var *capitata* (cabbage), *Brassica rapa* (mustard), *Citrus limon* (lemon), *C. sinensis* (sweet orange), *Daucus carota* (carrot), *Hordeum vulgare* (barley), *Nicotiana tabacum* (tobacco), *Oryza sativa* (rice), *Psidium guajava* (guava), *Saccharum officinarum* (sugarcane), *Solanum tuberosum* (potato), *Zingiber officinale* (ginger) (Kazi 1996; Orton Williams 1980; Zeidan & Geraert 1990; Bridge *et al*. 2005). *Helicotylenchus* nematodes are polyphagous (Luc *et al.* 1990).
Distribution	Fiji (Orton Williams 1980; Bridge 1988; Van den Berg & Kirby 1979), Egypt, Sudan (Zeidan & Geraert 1990), Pakistan (Kazi 1996), USA (Lehman 2002), Guadeloupe, Rwanda (Van den Berg *et al*. 2003)

Quarantine pest	***Helicotylenchus indicus*** Siddiqi, 1963
Synonyms	*Helicotylenchus plumariae* Khan & Basir, 1964 *Helicotylenchus persici* Saxena, Chhabra & Joshi, 1973 *Helicotylenchus microdorus* Prasad, Khan & Chawla, 1970 *Helicotylenchus thornei* Román, 1965
Common name(s)	Spiral nematode
Main hosts	*Abelmoschus esculentus* (okra), *Arachis hypogaea* (groundnut), *Barringtonia asiatica* (sea poison tree), *Brassica rapa* subsp. *chinensis* (Chinese cabbage), *Cajanus cajan* (pigeon pea), Capsicum frutescens (cayenne pepper), *Carica papaya* (pawpaw), *Citrus reticulata* (mandarin), *Citrus* spp., *Cocos nucifera* (coconut palm), *Colocasia esculenta* (taro), *Couroupita guianensis* (cannonball tree), *Curcuma longa* (turmeric), *Dioscorea alata* (white yam), *Euodia hortensis*, *Hernandia ovigera*, *Hibiscus manihot* (hibiscus root), *Ipomoea batatas* (sweet potato), *Lycopersicon esculentum* (tomato), *Mangifera indica* (mango), *Manihot esculenta* (cassava), *Manlkara zapota* (sapodilla), *Musa sapientum* (sweet banana), *Oryza sativa* (rice), *Nicotiana tabacum* (tobacco), *Panicum coloratum* (coloured Guinea grass), *Panicum maximum* (Guinea grass), *Paspalum conjugatum* (hilograss), *Piper aduncum* (spiked pepper), *Saccharum officinarum* (sugarcane), *Solanum melongena* (aubergine, eggplant), *Sorghum bicolor* (sorghum), *Sorghum vulgare* (broomcorn), *Tamarindus indica* (tamarind), *Tectona grandis* (teak), *Thevetia peruviana* (yellow oleander), *Xanthosoma sagittifolium* (yautia), *Zea mays* (maize) (Kazi 1996; Van den Berg and Kirby 1979; Orton Williams 1980; Bridge *et al*. 2005). *Helicotylenchus* species are polyphagous (Luc *et al.* 1990)
Distribution	Fiji (Orton Williams 1980; Bridge 1988; Van den Berg and Kirby 1979), Papua New Guinea, Samoa, Solomon Islands, Tonga (Bridge 1988); India, Pakistan (Kazi 1996)

Quarantine pest	***Helicotylenchus mucronatus*** Siddiqi, 1963
Synonyms	
Common name(s)	Spiral nematode
Main hosts	*Abelmoschus manihot*, *Aleurites moluccana*, *Allium cepa*, *Allium* sp., *Alocasia macrorrhizos*, *Alphitonia zizyphoides*, *Ananas comosus*, *Annona muricate*, *Arachis hypogaea*, *Bambusa vulgaris*, *Bauhinia monandra*, *Brassica* sp., *Broussonetia papyrifera*, *Cananga odorata*, *Capsicum frutescens*, *Carica papaya*, *Ceiba pentandra*, *Citrullus lanatus*, *Citrus limon*, *Citrus sinensis*, *Cocos nucifera*, *Codiaeum variegatum*, *Colocasia esculenta*, *Cordyline fruticose*, *Cucumis sativus*, *Cucumis* sp., *Cucurbita maxima*, *Cucurbita* sp., *Cyathea* sp., *Dioscorea alata*, *Dioscorea bulbifera*, *Dioscorea esculenta*, *Dioscorea nummularia*, *Dysoxylum forsteri*, *Elettaria cardamomum*, *Endospermum macrophyllum*, *Ficus tinctorial*, *Glochidion ramiflorum*, *Gmelina arborea*, *Grevillea banksii*, *Heliconia indica*, *Hibiscus tiliaceus*, *Inocarpus fagifer*, *Ipomoea batatas*, *Kleinhofia hospita*, *Lantana camara*, *Lycopersicon esculentum, Macadamia tetraphylla, Macaranga seemannii* var. *seemannii, Mangifera indica*, *Manihot esculenta*, *Miscanthus floridulus*, *Morinda citrifolia*, *Musa sapientum*, *Myristica inutilis*, *Nicotiana tabacum*, *Oryza sativa*, *Passiflora edulis*, *Persea americana*, *Piper methysticum*, *Piper puberulum*, *Pometia pinnata*, *Psidium guajava*, *Rhus taitensis*, *Saccharum edule*, *Saccharum officinarum*, *Sechium edule*, *Setaria palmifolia*, *Solanum tuberosum*, *Swietenia macrophylla*, *Syzygium richii*, *Tacca leontopetaloides*, *Tectona grandis*, *Theobroma cacao*, *Urena lobata*, *Vigna radiata*, *Xanthosoma sagittifolium*, *Zea mays*, *Zingiber officinale*, *Zingiber zerumbet* (Orton Williams 1980; Bridge 1988; Bridge and Page 1984).
Distribution	Asia: India (Mishra and Mandal 1989; Rama and Dasgupta 2000) Africa: Cameroon (Ali and Geraert 1975), Kenya (Waudo *et al*. 1998) Central America: Guadeloupe (Marais *et al*. 1999; Queneherve and Van den Berg 2005) Oceania: American Samoa, Fiji , Niue, Papua New Guinea, Solomon Islands, Tonga (Ecoport 2011), Samoa (Bridge 1988).

Quarantine pest	***Sphaeronema*** sp. (Raski & Sher, 1952)
Synonyms	*Goodeyella* sp. (Siddiqi, 1986) *Tumiota* sp. (Siddiqi, 1986)
Common name(s)	Cystoid nematode
Main hosts	*Ananas comosus* (pineapple), *Capsicum frutescens* (chilli), *Carica papaya* (pawpaw), *Citrus* spp., *Cocos nucifera* (coconut), *Cucurbita maxima* (giant pumpkin), *Hevea brasiliensis* (rubber tree), *Kleinhovia hospita* (guest tree), *Metroxylon solomonense* (Ivory nut palm), *Musa sapientum* (sweet banana), *Nerium oleander* (common oleander), *Pandanus* sp. (screw pine), *Rhus taitensis* (tavai), *Saccharum officinarum* (sugarcane), *Schizostachyum glaucifolium* (Hawaiian bamboo), *Swietenia macrophylla* (big leaved mahogany), *Terminalia catappa* (tropical almond), *Theobroma cacao* (cocoa) (Orton Williams 1980); *Opuntia stricta* (prickly pear) (McLeod *et al*. 1994); *Zingiber officinale* (Smith *et al.* 2007).
Distribution	Fiji, Kiribati, Samoa, Tonga (Bridge 1988; Orton Williams 1980).

Appendix C Biosecurity framework

Australia's biosecurity policies

The objective of Australia's biosecurity policies and risk management measures is the prevention or control of the entry, establishment or spread of pests and diseases that could cause significant harm to people, animals, plants and other aspects of the environment.

Australia has diverse native flora and fauna and a large agricultural sector, and is relatively free from the more significant pests and diseases present in other countries. Therefore, successive Australian Governments have maintained a conservative, but not a zero-risk, approach to the management of biosecurity risks. This approach is consistent with the World Trade Organization's (WTO's) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).

The SPS Agreement defines the concept of an 'appropriate level of protection' (ALOP) as the level of protection deemed appropriate by a WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory. Among a number of obligations, a WTO Member should take into account the objective of minimising negative trade effects in setting its ALOP.

Like many other countries, Australia expresses its ALOP in qualitative terms. Australia's ALOP, which reflects community expectations through Australian Government policy, is currently expressed as providing a high level of sanitary and phytosanitary protection, aimed at reducing risk to a very low level, but not to zero.

Consistent with the SPS Agreement, in conducting risk analyses Australia takes into account as relevant economic factors:

- the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease in the territory of Australia
- the costs of control or eradication of a pest or disease and
- the relative cost-effectiveness of alternative approaches to limiting risks.

Roles and responsibilities within Australia's quarantine system

Australia protects its human[4], animal and plant life or health through a comprehensive quarantine system that covers the quarantine continuum, from pre-border to border and post-border activities.

Pre-border, Australia participates in international standard-setting bodies, undertakes risk analyses, develops offshore quarantine arrangements where appropriate, and engages with our neighbours to counter the spread of exotic pests and diseases.

At the border, Australia screens vessels (including aircraft), people and goods entering the country to detect potential threats to Australian human, animal and plant health.

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[4] The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine.

The Australian Government also undertakes targeted measures at the immediate post-border level within Australia. This includes national co-ordination of emergency responses to pest and disease incursions. The movement of goods of quarantine concern within Australia's border is the responsibility of relevant state and territory authorities, which undertake inter- and intra-state quarantine operations that reflect regional differences in pest and disease status, as a part of their wider plant and animal health responsibilities.

Roles and responsibilities within the Department

The Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) is responsible for the Australian Government's animal and plant biosecurity policy development and the establishment of risk management measures. The Secretary of the department is appointed as the Director of Animal and Plant Quarantine under the *Quarantine Act 1908* (the Act).

DAFF takes the lead in biosecurity and quarantine policy development and the establishment and implementation of risk management measures across the biosecurity continuum, and:

- conducts risk analyses, including IRAs, and develops recommendations for biosecurity policy as well as providing quarantine policy advice to the Director of Animal and Plant Quarantine
- develops operational procedures, makes a range of quarantine decisions under the Act (including import permit decisions under delegation from the Director of Animal and Plant Quarantine) and delivers quarantine services
- coordinates pest and disease preparedness, emergency responses and liaison on inter- and intra-state quarantine arrangements for the Australian Government, in conjunction with Australia's state and territory governments.

Roles and responsibilities of other government agencies

State and territory governments play a vital role in the quarantine continuum. DAFF works in partnership with state and territory governments to address regional differences in pest and disease status and risk within Australia, and develops appropriate sanitary and phytosanitary measures to account for those differences. Australia's partnership approach to quarantine is supported by a formal Memorandum of Understanding that provides for consultation between the Australian Government and the state and territory governments.

Depending on the nature of the good being imported or proposed for importation, DAFF Biosecurity may consult other Australian Government authorities or agencies in developing its recommendations and providing advice.

As well as a Director of Animal and Plant Quarantine, the Act provides for a Director of Human Quarantine. The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine and Australia's Chief Medical Officer within that Department holds the position of Director of Human Quarantine. DAFF Biosecurity may, where appropriate, consult with that department on relevant matters that may have implications for human health.

The Act also requires the Director of Animal and Plant Quarantine, before making certain decisions, to request advice from the Environment Minister and to take the advice into account when making those decisions. The Australian Government Department of

Sustainability, Environment, Water, Population and Communities (DSEWPC) is responsible under the *Environment Protection and Biodiversity Conservation Act 1999* for assessing the environmental impact associated with proposals to import live species. Anyone proposing to import such material should contact DSEWPC directly for further information.

When undertaking risk analyses, DAFF Biosecurity consults with DSEWPC about environmental issues and may use or refer to DSEWPC's assessment.

Australian quarantine legislation

The Australian quarantine system is supported by Commonwealth, state and territory quarantine laws. Under the Australian Constitution, the Commonwealth Government does not have exclusive power to make laws in relation to quarantine, and as a result, Commonwealth and state quarantine laws can co-exist.

Commonwealth quarantine laws are contained in the *Quarantine Act 1908* and subordinate legislation including the Quarantine Regulations 2000, the Quarantine Proclamation 1998, the Quarantine (Cocos Islands) Proclamation 2004 and the Quarantine (Christmas Island) Proclamation 2004.

The quarantine proclamations identify goods, which cannot be imported, into Australia, the Cocos Islands and or Christmas Island unless the Director of Animal and Plant Quarantine or delegate grants an import permit or unless they comply with other conditions specified in the proclamations. Section 70 of the Quarantine Proclamation 1998, section 34 of the Quarantine (Cocos Islands) Proclamation 2004 and section 34 of the Quarantine (Christmas Island) Proclamation 2004 specify the things a Director of Animal and Plant Quarantine must take into account when deciding whether to grant a permit.

In particular, a Director of Animal and Plant Quarantine (or delegate):

- must consider the level of quarantine risk if the permit were granted, and
- must consider whether, if the permit were granted, the imposition of conditions would be necessary to limit the level of quarantine risk to one that is acceptably low, and
- for a permit to import a seed of a plant that was produced by genetic manipulation – must take into account any risk assessment prepared, and any decision made, in relation to the seed under the Gene Technology Act, and
- may take into account anything else that he or she knows is relevant.

The level of quarantine risk is defined in section 5D of the *Quarantine Act 1908*. The definition is as follows:

> reference in this Act to a *level of quarantine risk* is a reference to:
>
> (a) the probability of:
>
> (i) a disease or pest being introduced, established or spread in Australia, the Cocos Islands or Christmas Island; and
>
> (ii) the disease or pest causing harm to human beings, animals, plants, other aspects of the environment, or economic activities; and
>
> (b) the probable extent of the harm.

The Quarantine Regulations 2000 were amended in 2007 to regulate keys steps of the import risk analysis process. The Regulations:

- define both a standard and an expanded IRA,
- identify certain steps, which must be included in each type of IRA,
- specify time limits for certain steps and overall timeframes for the completion of IRAs (up to 24 months for a standard IRA and up to 30 months for an expanded IRA),
- specify publication requirements,
- make provision for termination of an IRA, and
- allow for a partially completed risk analysis to be completed as an IRA under the Regulations.

The Regulations are available at www.comlaw.gov.au.

International agreements and standards

The process set out in the *Import Risk Analysis Handbook 2007 (update 2011)* is consistent with Australia's international obligations under the SPS Agreement. It also takes into account relevant international standards on risk assessment developed under the International Plant Protection Convention (IPPC) and by the World Organisation for Animal Health (OIE).

Australia bases its national risk management measures on international standards where they exist and when they achieve Australia's ALOP. Otherwise, Australia exercises its right under the SPS Agreement to apply science-based sanitary and phytosanitary measures that are not more trade restrictive than required to achieve Australia's ALOP.

Notification obligations

Under the transparency provisions of the SPS Agreement, WTO Members are required, among other things, to notify other members of proposed sanitary or phytosanitary regulations, or changes to existing regulations, that are not substantially the same as the content of an international standard and that may have a significant effect on trade of other WTO Members.

Risk analysis

Within Australia's quarantine framework, the Australian Government uses risk analyses to assist it in considering the level of quarantine risk that may be associated with the importation or proposed importation of animals, plants or other goods.

In conducting a risk analysis, DAFF Biosecurity:

- identifies the pests and diseases of quarantine concern that may be carried by the good
- assesses the likelihood that an identified pest or disease or pest would enter, establish or spread
- assesses the probable extent of the harm that would result.

If the assessed level of quarantine risk exceeds Australia's ALOP, DAFF Biosecurity will consider whether there are any risk management measures that will reduce quarantine risk to achieve the ALOP. If there are no risk management measures that reduce the risk to that level, trade will not be allowed.

Risk analyses may be carried out by DAFF Biosecurity's specialists, but may also involve relevant experts from state and territory agencies, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), universities and industry to access the technical expertise needed for a particular analysis.

Risk analyses are conducted across a spectrum of scientific complexity and available scientific information. An IRA is a type of risk analysis with key steps regulated under the Quarantine Regulations 2000. DAFF Biosecurity's assessment of risk may also take the form of a non-regulated analysis of existing policy or technical advice. Further information on the types of risk analysis is provided in the *Import Risk Analysis Handbook 2007 (update 2011)*.

7 Glossary

Term or abbreviation	Definition
Additional declaration	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information on a consignment in relation to regulated pests (FAO 2010).
Appropriate level of protection (ALOP)	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995).
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2010).
Area of low pest prevalence	An area, whether all of a country, part of a country, or all parts of several countries, as identified by the competent authorities, in which a specific pest occurs at low levels and which is subject to effective surveillance, control or eradication measures (FAO 2010).
Certificate	An official document which attests to the phytosanitary status of any consignment affected by phytosanitary regulations (FAO 2010).
Consignment	A quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) (FAO 2010).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2010).
DAFF Biosecurity	The unit, within the Department of Agriculture, Fisheries and Forestry, responsible for Australia's biosecurity policies. Previously known as the Biosecurity Australia and the Australian Quarantine and Inspection Service (AQIS).
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2010).
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO 2010).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2010).
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2010).
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2010).
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2010).
Import risk analysis	An administrative process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present and/or to determine compliance with phytosanitary regulations (FAO 2010).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used (FAO 2010).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2010).
International Standard for Phytosanitary Measures (ISPM)	An international standard adopted by the Conference of the Food and Agriculture Organization, the Interim Commission on phytosanitary measures or the Commission on phytosanitary measures, established under the IPCC (FAO 2010).
Introduction	The entry of a pest resulting in its establishment (FAO 2010).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment (FAO 2010).
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2010).
Official control	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2010).
Pathway	Any means that allows the entry or spread of a pest (FAO 2010).

Term or abbreviation	Definition
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2010).
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2010).
Pest free area (PFA)	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2010).
Pest free place of production	Place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period (FAO 2010).
Pest free production site	A defined portion of a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this conditions is being officially maintained for a defined period and that is managed as a separate unit in the same way as a pest free place of production (FAO 2010).
Pest risk analysis (PRA)	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it (FAO 2010).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences (FAO 2010).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2010).
Phytosanitary certificate	Certificate patterned after the model certificates of the IPPC (FAO 2010).
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2010).
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2010).
Polyphagous	Feeding on a relatively large number of hosts from different genera.
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2010).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO 2010).
Regulated article	Any plant, plant product, storage place, packing, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2010).
Restricted risk	Risk estimate with phytosanitary measure(s) applied.
Spread	Expansion of the geographical distribution of a pest within an area (FAO 2010).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995).
Stakeholders	Government agencies, individuals, community or industry groups or organizations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues.
Systems approach(es)	The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection against regulated pests (FAO 2010).
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk mitigation measures.

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