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Department of Agriculture, Fisheries and Forestry

Final import risk analysis report for fresh ginger from Fiji

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

Contents

Tables

Figures

Figure 1 Map of Australia

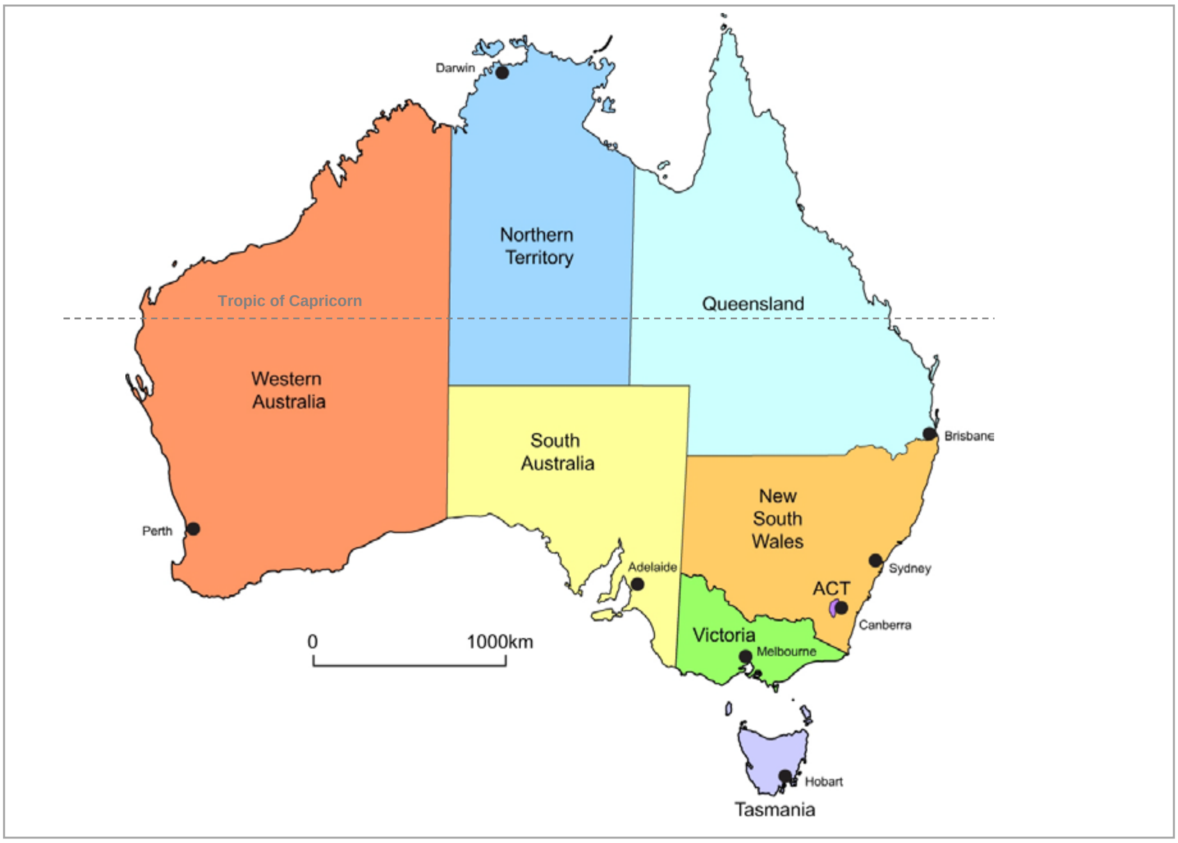
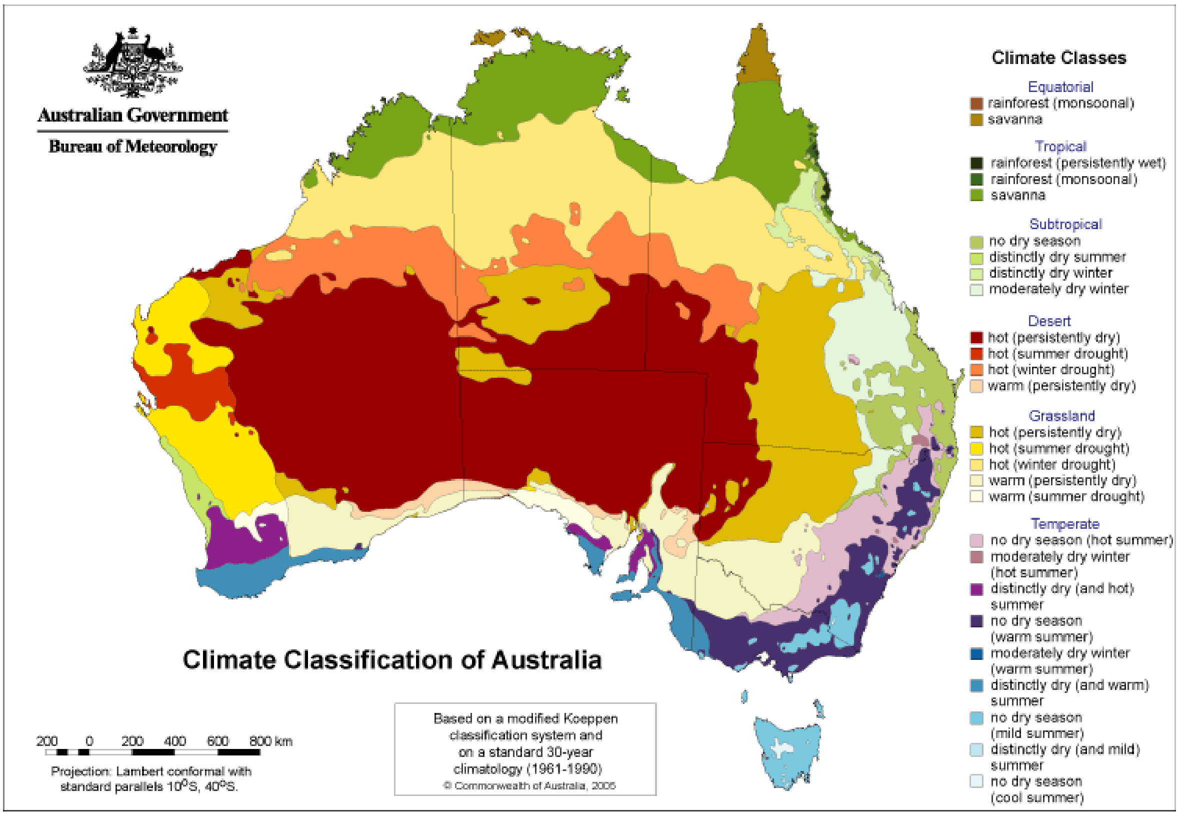


Figure 2 A guide to Australia’s bio-climate zones



Acronyms and abbreviations

Term or abbreviation	Definition
AGIA	Australian Ginger Industry Association
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
DAFF Queensland	Department of Agriculture, Fisheries and Forestry, Queensland Government
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 (DAFF) has assessed the quarantine risks associated with the importation of fresh ginger (*Zingiber officinale*) rhizomes from Fiji. This final 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.

In addition, the burrowing nematode, *Radopholus similis* - putative intraspecific ginger variant, has been provisionally accepted as a quarantine pest based on new, but incomplete information. A systems approach to manage burrowing nematode is recommended. Alternatively, importers may elect to fumigate ginger consignments. Ginger rhizomes must be subject to phytosanitary inspection to ensure that consignments are free of *Radopholus similis* - putative intraspecific ginger variant, or any other regulated articles. Consistent with its provisional acceptance, the quarantine status and measures for this pest will be reviewed after one year, or in the event that new information becomes available.

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. Where quarantine pests or other regulated articles are detected, consignments will be subject to appropriate remedial action.

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 (DAFF) using teams of technical and scientific experts in relevant fields, and involves consultation with stakeholders at various stages during the process. DAFF 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 D of this report and in the *Import Risk Analysis Handbook 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 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 Chapter 3. No mandated or industry accredited schemes are in place for ginger production in Fiji. Therefore, the assumption in both the current and draft reports has been that these production practices are not enforced in Fiji.

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.

Australia has general requirements for all fruit and vegetables, which require that consignments must be free of live insects, disease symptoms, trash, contaminant seeds, soil and other debris on arrival in Australia. The assessment of soil contamination is beyond the scope of this analysis.

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

The draft report was released on 16 April 2012 (BAA 2012/07) for comment and consultation with stakeholders, for a period of 60 days that concluded on 15 June 2012.

On 31 May 2012 DAFF meet with representatives from the AGIA and DAFF Queensland to discuss the draft report and submission process

Written submissions were received from ten stakeholders. Submissions have been considered and material matters raised have been included in the present report. DAFF also met with AGIA and DAFF Queensland representatives on 26 July 2012 to discuss their submissions prior to finalisation of the provisional IRA report.

DAFF also consulted informally with stakeholders, including Australian Ginger Industry Association and the Biosecurity Authority of Fiji, during the preparation of the final report.

A summary of the major scientific issues raised in stakeholder submissions is presented in Appendix C.

2 Method for pest risk analysis

This section sets out the method used for the pest risk analysis (PRA) in this report. DAFF has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2007) and ISPM 11: *Pest Risk Analysis for Quarantine Pests, including analysis of environmental risks and living modified organisms* (FAO 2004).

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 2012). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2012).

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 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 2012).

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 2012).

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 2012).

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 2004). 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 when estimating the probability of entry.

For the purpose of considering the probability of entry, DAFF 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 (such as bulk or 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 (such as 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 (such as 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 (for example 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 2012). In order to estimate the probability of establishment of a pest, reliable biological information (for example, lifecycle, host range, epidemiology, survival) 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 2012). 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 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	$0.7 < P \le 1$
Moderate	The event would occur with an even probability	$0.3 < P \le 0.7$
Low	The event would be unlikely to occur	$0.05 < P \le 0.3$
Very low	The event would be very unlikely to occur	$0.001 < P \le 0.05$
Extremely low	The event would be extremely unlikely to occur	$0.000001 < P \le 0.001$
Negligible	The event would almost certainly not occur	$0 \le P \le 0.000001$

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 (for example ‘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 (for example ‘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 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'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 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 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 2012) and ISPM 11 (FAO 2004).

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
- 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.

2.2.4 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.

[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

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (such as 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 2004) 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 – 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 – 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 – pest-free area, pest-free place of production or pest-free production site
- options for other types of pathways – consider natural spread, measures for human travellers and their baggage, cleaning or disinfestation of contaminated machinery
- options within the importing country – 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 Commercial ginger production in Fiji

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 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.

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

3.2.1 Cultivation practices

A general overview of cultivation practices follows. These practices are not part of mandated government programs, or industry accredited schemes.

Ginger is an annual crop that is planted in the spring, and usually grown in rotation with cassava and taro (Buresova and McGregor 1990; MPI 2011; Smith *et al*. 2012). Both cassava and taro are poor hosts of parasitic nematodes such as *Radopholus similis*, *Rotylenchulus reniformis* and *Meloidogyne* spp. (Turaganivalu *et al*. 2010; Smith *et al*. 2012), so crop rotation assists in management of pest nematode populations. In addition to the crop rotation, a fallow period is usually included in the program so that ginger is only grown in the same plot once in every three to four years (MPI 2011). Ginger production is very labour intensive. Traditionally much of the land preparation and harvesting was done by hand (Buresova and McGregor 1990), but is increasingly becoming mechanised. 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. However, this may contribute to disease build up within the farm if effective seed treatments are not employed to ensure clean planting material. The seed rhizomes are cut or broken into pieces, each around 60–70 g, with at least two eyes (Figure 3.3) (MPI 2011).

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, some farmers have abandoned this process, or are performing it ineffectively.

The seed pieces are left to dry for 8–10 days before planting, allowing any cuts on the rhizomes to heal, which reduces rhizome susceptibility to pathogens in the soil after planting (MPI 2011; Smith *et al*. 2012). 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 (MPI 2011).

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 ginger) for processing into products such as ginger in brine. This minimises losses caused by rotting, because the soils can become waterlogged in the lowland production areas. Immature ginger is harvested within six to 6.5 months. Mature ginger from the highlands is harvested at ten to twelve months (Buresova and McGregor 1990). The ginger rhizomes are harvested 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 high pressure water 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 10–13 °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 to New Zealand

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 2011a). Table 3.1 shows production data for the last six years for which data is available.

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

Year	2004	2005	2006	2007	2008	2009	2010
Tonnes (t)	3770	3652	3209	3111	2448	3041	2338

3.3.2 Export statistics

Fiji exports fresh ginger to the United States and New Zealand (McGregor 2007). Export figures (both fresh and processed) 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 (fresh and processed) from Fiji (FAO 2011a)

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

Exports statistic sourced from the Fiji Department of Agriculture; Economics, Planning and Statistics Division indicate that total ginger exports amounted to 1037 t in 2009 and 1003 t in 2010. Of these, fresh ginger exports (predominantly to Germany, Netherlands, United Kingdom, New Zealand and United States) amounted to 74 t in 2009 and 161 t in 2010.

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 nine 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	
Radopholus similis – putative intraspecific ginger variant	Burrowing nematode
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.) bulbs, kava (*Piper methysticum*) stems, cycad (*Cycas* spp.) trunks, ti (*Cordyline fruticosa*) cuttings, lemon (*Citrus limon*) fruit, dwarf mondo (*Ophiopogon japonicus*) roots, *Marattia* fern trunks and dead sugarcane (*Saccharum* spp.) (Follett *et al*. 2007; Mau and Martin Kessing 1992a). Some of these host records are, however, from dead or dying plants (sugarcane, cycad), fallen fruit on the ground (avocado), and commodities in storage or transit (taro, lemon, ginger, sweet potato), rather than living plants (Swezey 1952).

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 was reported as a serious pest in localised areas in Tonga in 1979, where it was recorded attacking stems of kava (Fakalata 1981). The opening of extensive forest areas for planting kava and poor farming practices contributed to the pest outbreak and resulting crop damage (Fakalata 1981). Previously no action had been taken to control the weevil as the damage was not considered to be economically significant (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 tubers 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: **HIGH**.

- 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. Rhizomes affected by feeding damage would be less likely to sprout and develop into mature plants.
- 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: **HIGH**.

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**.

- In two consignments of infested lemons, Miller (1923) reported that only a single egg was laid in each fruit, so each fruit only contained a single larva. It is not known if this behaviour also occurs on ginger rhizomes.
- 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 (possibly oviposited by multiple females, as each female may lay 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.
- There are no recent records of this pest establishing in new locations. Reports of this pest are historical, mostly dating from the late 1800s and early 1900s. It was recorded in Fiji in 1881, Samoa in 1912, Hawaii in 1918, Cook Islands in 1923 and Tahiti in 1950. Despite the significant increase in international movement of plant commodities over the last fifty years, there is little evidence of *Elytroteinus subtruncatus* successfully establishing beyond its endemic distribution.

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). While damage is usually of no economic significance, there have been isolated reports of it being a major pest of kava in Tonga (Fakalata 1981) and causing ‘much damage’ to begonias in Fiji (Simmonds 1928). Records of association with some hosts are for dead plant material (sugarcane), fallen fruit (avocado) or plant material in storage or transit (lemons, taro, ginger, sweet potato) (Swezey 1952; Follett *et al*. 2007).
Other aspects of the environment	**Impact score**: A – indiscernible at the local level This weevil is not reported to have any direct effect on non-plant health related aspects of the environment such as impacts on other fauna, soil, water, buildings and other infrastructure.
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 (for example, removal of affected plants). 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.

Criterion	Estimate and rationale
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 There is no evidence from areas where this pest is present to indicate it would have significant indirect impacts on the environment or non-commercial activities such as: significant effects on plant communities, environmentally sensitive areas, changes in ecological processes or ecosystem ability, effects on human use, or environmental restoration costs. Potential impacts to plant life are likely to be minor and localised and would not result in discernible changes to plant communities, ecological processes or human recreational uses.

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), although a review by Abdulla Koya *et al*. (1991) suggests that females can also reproduce parthenogenetically. 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: **HIGH**.

- 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), although parthenogenetic reproduction may also occur (Abdulla Koya *et al*. 1991).
- 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: **HIGH.**

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**: A – indiscernible 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 a direct effect on non-plant health related aspects of the environment such as impacts on other fauna, soil, water, buildings and other infrastructure.
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 There is no evidence from areas where this pest is present to indicate it would have significant indirect impacts on the environment or non-commercial activities such as: significant effects on plant communities, environmentally sensitive areas, changes in ecological processes or ecosystem ability, effects on human use, or environmental restoration costs. Potential impacts to plant life are likely to be minor and localised and would not result in discernible changes to plant communities, ecological processes or human recreational uses.

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 Burrowing nematode ginger variety

Radopholus similis – putative intraspecific ginger variant

Information was provided by the Australian Ginger Industry Association (AGIA) and Department of Agriculture Fisheries and Forestry Queensland (DAFF Queensland) researchers through stakeholder submissions on the draft IRA report and subsequent consultation that a new, yet to be described, intraspecific variant of burrowing nematode, (*Radopholus similis*), is likely present in Fiji.

The characteristics of this putative intraspecific ginger variant, as described by the DAFF Queensland researchers, are: 1) The Fijian variant is highly pathogenic on ginger, while banana is a poor host. 2). In contrast, the Australian variant is highly pathogenic on banana, while ginger is a poor host (Mike Smith, Jenny Cobon, DAFF Queensland, *personal communication*).

Article 5 of the SPS agreement states:

> In cases where relevant scientific evidence is insufficient, a Member may provisionally adopt sanitary or phytosanitary measures on the basis of the available pertinent information, including that from the relevant international organizations, as well as from sanitary or phytosanitary measures applied by other Members. In such circumstances, Members shall seek to obtain the additional information necessary for a more objective assessment or risk and review the sanitary or phytosanitary measure accordingly within a reasonable period of time.

On this basis the submissions of AGIA and DAFF Queensland on *Radopholus similis* have been provisionally accepted and the pest risk assessment for *Radopholus similis* - putative intraspecific ginger variant has been included in the IRA. This assessment is conducted on the basis that *Radopholus similis* - putative intraspecific ginger variant is a new pest at the intraspecific level and should not be interpreted as prejudicing existing policy for *Radopholus similis*.

A full discussion of the submissions and the DAFF response in relation to this issue is included in Appendix C of this report.

The following information relates to the polyphagous *Radopholus similis*, which has a wide international distribution, including Australia.

Radopholus similis is a migratory endoparasitic nematode, found in most banana-growing regions of the world (Marin *et al*. 1998). The international dissemination of *Radopholus similis* is a relatively recent event, probably starting in the late nineteenth century or early twentieth century with the movement of banana corms (Marin *et al*. 1998).

The lifecycle of *Radopholus similis* consists of the egg, four juvenile stages and the adult (Stirling and Stanton 1997). The first juvenile stage develops within the egg, moulting before emergence as a second stage juvenile (Brooks 2008). Both males and females are present in the population, and sexual reproduction is the norm, although hermaphrodism is an alternative reproductive strategy in *Radopholus similis*. Self-fertilisation takes place around 50–60 days after the fourth moult in females that have not mated (Kaplan and Opperman 2000). The lifecycle can be completed in as little as 20–25 days at 24–32 °C (Stirling and Stanton 1997).

Each female lays around 4–5 eggs per day for two weeks (Marin *et al*. 1998). The eggs are reported to hatch in 8–10 days (Brooks 2008).

All life stages of *Radopholus similis* develop within the host tissue. However, adult males have degenerate stylets and do not feed. Adult males are unable to penetrate the root tissue, although they may still be found inside roots if juvenile nematodes undergo their final moult within the root tissue (Stirling and Stanton 1997).

Adult females and juveniles usually penetrate the root near the tip, and can migrate along the length of the root. In banana it invades the cortical cells, and feeds and reproduces within the cortex of the roots and corm. It burrows between the cortical cells, puncturing the cell walls with its stylet to feed on the cytoplasm (Marin *et al*. 1998). Feeding destroys the cells, resulting in extensive cavities in the roots or other tissues. The nematodes migrate away from necrotic tissues, expanding the affected area as they tunnel within the roots to feed (Stirling and Stanton 1997). The root cavities coalesce to form dark red lesions, which turn black as other organisms invade the tissues (Stirling and Stanton 1997). Secondary invasion by fungi, bacteria and microbivorous nematodes hastens the destruction of the roots (Marin *et al*. 1998). The female lays eggs in the decaying tissues (Brooks 2008).

Radopholus similis has a wide recognised host range, with more than 350 plant hosts reported (Brooks 2008). It is associated with crops, particularly banana, but also black pepper, coconut, coffee, ginger, pineapple, sugarcane and tea. It also survives on many weedy plant species that grow in the vicinity of crop species (EPPO 1990). Ginger is reported as a host in Hawaii (Sipes *et al*. 2001), India (Sundararaju *et al*. 1979) and Fiji (Turaganivalu *et al*. 2009), and the nematode has been found on ginger in Australia (Mike Smith, DAFF Queensland, *personal communication*). Cobon *et al*. (2012 *in press*) demonstrated that an Australian isolate survived on ginger in an experimental trial.

Differences in host preference between *Radopholus similis* populations have commonly been observed, but the only intraspecific variants recognised from a quarantine perspective are the citrus and non-citrus hosting pathotypes/races (Kaplan *et al*. 2000). Even though there is relatively little genetic diversity (Tan *et al*. 2010) within the surveyed Australian *Radopholus similis* population, different Australian isolates have varying levels of pathogenicity and the presence of more than one pathotype has been speculated (Cobon and Pattison 2003).

4.3.1 Probability of entry

Probability of importation

The likelihood that *Radopholus similis* - putative intraspecific ginger variant will arrive in Australia with the importation of fresh ginger from Fiji is: **MODERATE**.

- *Radopholus similis* is a migratory endoparasitic feeder, and can be found just below the surface of the ginger rhizomes. It is likely to remain within the rhizome after harvest, so if not detected could be imported with consignments of fresh ginger.
- The nematode is primarily a problem where there has been poor seed preparation and crop management practices. Pre-planting seed treatment, rotation cropping and removal of weeds and volunteer plants effectively controls nematode populations to below detectable levels (Smith *et al*. 2012).
- Incipient infections of rhizomes result in small shallow water-soaked lesions (Vilsoni *et al*. 1976). These lesions spread and secondary organisms invade the tissues, causing

extensive rotting. Obviously infested or rotting rhizomes would be discarded at harvest. Rhizomes with lesions or other symptoms of nematodes are likely to be culled during pre-export processing/packing, or detected during phytosanitary inspection.

- The nematodes are tiny, with the adults only around 0.75 mm in length (Sipes *et al*. 2001), so if they were present in small numbers without visible symptoms, it is possible they would not be detected.
- The experience of Fiji's ginger exports to other markets over a number of years does not suggest a high likelihood that *Radopholus similis* would be present in export-quality ginger.

Probability of distribution

The likelihood that *Radopholus similis* - putative intraspecific ginger variant 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**.

- Dispersal over long distances is most likely to occur with distribution of infested ginger rhizomes. *Radopholus similis* is an endoparasitic feeder that will remain within the rhizome.
- *Radopholus similis* could survive inside the rhizomes for a considerable period of time.
- 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.
- *Radopholus similis* is an obligate parasite and requires a living host for survival in the soil (Brooks 2008), but could possibly survive in the soil for more than six weeks in the absence of a suitable host (EPPO 1990) and up to six months in decomposing plant material (Blake 1969, cited in Stirling and Pattison 2008).
- Some nematodes could potentially be introduced to the soil if consumers planted rhizomes in backyard gardens. 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 *Radopholus similis* - putative intraspecific ginger variant 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**.

4.3.2 Probability of establishment

The likelihood that *Radopholus similis* - putative intraspecific ginger variant 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**.

- The main risk for establishment is posed by the planting of infested rhizomes that would provide a living host on which the nematodes could reproduce.
- *Radopholus similis* is highly polyphagous, with more than 350 plant hosts recorded (Brooks 2008).
- Sexual reproduction is the norm, but hermaphrodism is also reported (Kaplan and Opperman 2000) so males would not be necessary to establish a population.
- *Radopholus similis* has already shown its capacity to establish in Australia following earlier introductions on banana (Marin *et al*. 1998; Tan *et al*. 2010).

4.3.3 Probability of spread

The likelihood that *Radopholus similis* - putative intraspecific ginger variant 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**.

- *Radopholus similis* has already shown its capacity to spread within Australia. It is widespread geographically within Australia, particularly in the tropical regions of Queensland, Northern Territory and Western Australia, but it is also found in New South Wales and South Australia (EPPO 1990; McLeod *et al*. 1994).
- *Radopholus similis* may spread wherever suitable host plants and favourable climate occur. However, the nematode has limited capacity for natural spread, and it is mostly associated with the movement of infested plant material and accompanying soil (EPPO 1990).

4.3.4 Probability of entry, establishment and spread

The likelihood that *Radopholus similis* - putative intraspecific ginger variant 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.**

4.3.5 Consequences

Assessment of the potential consequences (direct and indirect) of *Radopholus similis* - putative intraspecific ginger variant for Australia is: **LOW.**

Criterion	Estimate and rationale
Direct	
Plant life or health	**Impact score**: D – significant at the district level *Radopholus similis* - putative intraspecific ginger variant may have an impact on ginger production where poor crop management and production practices are in place. *Radopholus similis* - putative intraspecific ginger variant was not detectable in crops that employed crop rotation with non-host crops and which used hot water treated seed planting material (Turaganivalu *et al*. 2009). Infestation results in stunted, chlorotic low yielding crops (Vilsoni *et al*. 1976). Rhizomes can be completely destroyed (Turaganivalu *et al*. 2009).
Other aspects of the environment	**Impact score**: A – indiscernible at the local level *Radopholus similis* - putative intraspecific ginger variant is unlikely to have a direct effect on non-plant health related aspects of the environment such as impacts on other fauna, soil, water, buildings and other infrastructure.
Indirect	
Eradication, control etc.	**Impact score**: B – minor significance at the local level *Radopholus similis* is already present in Australia, and existing pest control measures would be effective. Specifically for ginger, the existing seed preparation and crop management techniques used against root knot nematodes and other pests would control *Radopholus similis* to below detectable levels without significant additional cost.
Domestic trade	**Impact score**: C – minor significance at the district level Recognition of intraspecific variants of *Radopholus similis* could potentially see states regulating the interstate movement of root crops and other plant material.
International trade	**Impact score**: C – minor significance at the local level Australia already manages *Radopholus similis* in international trade. Recognition of the nematode in Australia as being different to that in other countries poses challenges for gaining market access. Recognition of a ginger-specific race would make exporting ginger difficult were this nematode to establish in Australia.
Environmental and non-commercial	**Impact score**: A – indiscernible at the local level There is no evidence to indicate that *Radopholus similis* - putative intraspecific ginger variant would have significant indirect impacts on the environment or non-commercial activities. Existing populations of the nematode in Australia and elsewhere are not associated with impacts to native plants or communities. Potential impacts to plant life are likely to be minor and localised and would not result in discernible changes to plant communities, ecological processes or human recreational uses.

4.3.6 Unrestricted risk estimate

The unrestricted risk for *Radopholus similis* - putative intraspecific ginger variant 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 *Radopholus similis* - putative intraspecific ginger variant of ‘low’ exceeds Australia’s ALOP. Therefore, specific risk management measures are required for this pest.

4.4 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).

4.4.1 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**.

4.4.2 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.

4.4.3 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).

4.4.4 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**.

4.4.5 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, rendering them susceptible to other pests and pathogens. Ring nematodes are chronic pests of turf grasses on golf courses (CABI 2012). 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 not reported to have any direct effect on non-plant health related aspects of the environment such as impacts on other fauna, soil, water, buildings and other infrastructure.
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 2012). Economic impact on commercial orchard crops is more apparent (CABI 2012). 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 (for example 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.

Criterion	Estimate and rationale
Environmental and non-commercial	**Impact score**: B – minor significance at the local level There is no evidence from areas where ring nematodes are present to indicate they would have significant indirect impacts on the environment or non-commercial activities such as: significant effects on plant communities, environmentally sensitive areas, changes in ecological processes or ecosystem ability, effects on human use, or environmental restoration costs. Potential impacts to plant life are likely to be minor and localised and would not result in discernible changes to plant communities, ecological processes or human recreational uses. While there is no information on damage caused by the species being assessed, as a group ring nematodes have been associated with moderate damage to turfgrass roots at high population densities. This can make turf more susceptible to other stresses such as nutrient deficiencies and high temperatures, which could affect facilities such as golf courses (Stirling and Stirling 2000). There are already a number of other ring nematodes present in Australia.

4.4.6 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.

4.5 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 2012; 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 (for example 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.

4.5.1 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 2012).

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**.

4.5.2 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 parthenogenetically (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).

4.5.3 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.

4.5.4 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**.

4.5.5 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 2012). Spiral nematode feeding also increases host susceptibility to infection by bacteria (particularly *Pseudomonas* sp.), and fungi such as *Phytophthora cinnamomi* (CABI 2012).
Other aspects of the environment	**Impact score**: A – indiscernible at the local level Spiral nematodes are not reported to have any direct effect on non-plant health related aspects of the environment such as impacts on other fauna, soil, water, buildings and other infrastructure.

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 There is no evidence from areas where spiral nematodes are present to indicate they would have significant indirect impacts on the environment or non-commercial activities such as: significant effects on plant communities, environmentally sensitive areas, changes in ecological processes or ecosystem ability, effects on human use, or environmental restoration costs. Potential impacts to plant life are likely to be minor and localised and would not result in discernible changes to plant communities, ecological processes or human recreational uses.

4.5.6 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.

4.6 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).

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*. 2007a). These nematodes were not identified to the 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*. 2007a). Although the numbers of nematodes found were relatively low, they nevertheless indicate a potential risk of importation and spread in ginger.

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 pre-adult 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, possibly the same as the one found on ginger in 2007, has previously been reported in Fiji on citrus, rubber, screw pine, sugarcane, mahogany and cocoa (Orton Williams 1980). It was not considered to be common, and was mainly found in uncultivated soils (Orton Williams 1980). *Sphaeronema* sp. nematodes have also been associated with a number of plant hosts in other Pacific Island countries, including pineapple, breadfruit, chilli, pawpaw, coconut, pumpkin, banana and yardlong bean (Orton Williams 1980). It is not clear if the unidentified *Sphaeronema* nematodes identified in the Pacific surveys represent more than one *Sphaeronema* species.

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

4.6.1 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, or embedded in the skin of the rhizome, rather than deep within the rhizome. The adult females do not move once they have commenced feeding, and are not reported to migrate within plant tissues.
- Adult females could be present in the rhizome skin or on any roots not removed from the rhizomes.
- The females are embedded in the rhizome tissue, with only the posterior protruding from the surface, so may not be removed during postharvest cleaning processes.
- It is possible that some eggs, juveniles and males could be present on poorly cleaned rhizomes, 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.
- While the true host range of the cystoid nematode feeding on ginger in Fiji is yet to be determined, *Sphaeronema* species in the Pacific have 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**.

4.6.2 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.

4.6.3 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.* 2007a).
- 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).

4.6.4 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**.

4.6.5 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 Fiji has been found on at least seven plant hosts including citrus, rubber, screw pine, sugarcane, mahogany and cocoa (Orton Williams 1980) as well as ginger. 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 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 has been incorrectly attributed to other pests. There are pest species in the genus elsewhere in the world. *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 not reported to have any direct effect on non-plant health related aspects of the environment such as impacts on other fauna, soil, water, buildings and other infrastructure.
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 (for example 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 (for example 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 There is no evidence from areas where this pest is present to indicate it would have significant indirect impacts on the environment or non-commercial activities such as: significant effects on plant communities, environmentally sensitive areas, changes in ecological processes or ecosystem ability, effects on human use, or environmental restoration costs. Potential impacts to plant life are likely to be minor and localised and would not result in discernible changes to plant communities, ecological processes or human recreational uses.

4.6.6 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.

4.7 Pest risk assessment conclusion

The unrestricted risk posed by *Aspidiella hartii* and *Radopholus similis* - putative intraspecific ginger variant is estimated to exceed Australia's ALOP. Therefore, management measures for these pests 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]	Direct		Indirect				Overall	
	Importation	Distribution	Overall				PLH	OE	EC	DT	IT	ENC		
Weevils [Coleoptera: Curculionidae]														
Elytroteinus subtruncatus	H	H	H	L	M	L	C	A	B	B	B	A	VL	**N**
Armoured scales [Hemiptera: Diaspididae]														
Aspidiella hartii	H	H	H	H	H	H	D	A	B	C	B	A	L	**L**
Burrowing nematodes [Tylenchida: Pratylenchidae]														
Radopholus similis - putative intraspecific ginger variant	M	H	M	H	H	M	D	A	B	C	C	A	L	**L**
Ring nematodes [Tylenchida: Criconematidae]														
Discocriconemella discolabia *Mesocriconema denoudeni*	L	L	VL	H	H	VL	D	A	C	B	B	B	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 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:

- pre-export phytosanitary inspection by BAF for *Aspidiella hartii* to ensure that infested ginger rhizomes 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. Note that fumigation for *Radopholus similis* - putative intraspecific ginger variant will also be effective for yam scale.

5.1.2 Management for burrowing nematode (provisional)

The burrowing nematode, *Radopholus similis* - putative intraspecific ginger variant, 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 *Radopholus similis* - putative intraspecific ginger variant is the importation of live nematodes 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. The use of clean seed, application of manure and rotation of crops have been shown to reduce burrowing nematode populations to undetectable levels (Turaganivalu *et al*. 2012).

It is proposed that the risk of *Radopholus similis* - putative intraspecific ginger variant in ginger exported to Australia be managed by either:

1) a systems approach, such as, but not limited to:
   - the use of clean seed certified as nematode-free, or seed dipped in hot water at 51 °C for ten minutes, and either
   - a crop rotation program using non-crop hosts and fallow period, or
   - production in a recognised area of low pest prevalence

or

2) methyl bromide fumigation or other suitable treatment of rhizomes, either in Fiji or on arrival in Australia.

The objective of these measures is to reduce the likelihood of importation for *Radopholus similis* - putative intraspecific ginger variant to at least ‘low’. The restricted risk would then be reduced to ‘very low’, which would achieve Australia’s ALOP.

Under Article 5 of the SPS agreement where there is insufficient information provisional phytosanitary measures may be adopted by members on the basis of available information. Members are however obliged to seek additional information for a more objective assessment of the risk and conduct a review of any measures within a reasonable time.

Radopholus similis - putative intraspecific ginger variant has been provisionally included as a quarantine pest based on the uncertainty of information surrounding its status (See Appendix C). DAFF is obliged to review these conditions within a reasonable time. This has been determined to be a period of one year from the implementation of policy. If the review does not support the taxonomic retention of the *Radopholus similis* - putative intraspecific ginger variant, the measures will be reconsidered.

5.1.3 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 and treatment providers

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
- treatment facilities from which ginger is exported can be identified so investigation and corrective action can be targeted 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 (for example 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 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 inspection and 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 2011), to provide formal documentation to DAFF 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 with an additional declaration that the ginger has been produced in Fiji in accordance with the conditions governing entry of fresh ginger to Australia.

DAFF inspection

DAFF 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. Alternatively DAFF officers may undertake inspection in Fiji prior to export. 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 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

Policy on unidentified disease symptoms

Australia has a long standing policy of requiring treatment for diseased material where identification of the pathogens responsible is not possible. Where diseased commodities are detected and identification of the pathogens is not possible, or cannot be provided within a practical time, then the product is deemed to pose a disease risk to Australia and remedial action is required.

Remedial action(s) for non-compliance detected on-arrival in Australia

Where inspection lots are found to be non-compliant with requirements on-arrival in Australia, remedial action must be taken. The remedial actions for consignments (subject to on-arrival inspection) where quarantine pests are detected will depend on the type of pest and the mitigation measure that the risk assessment has determined for that specific pest. Remedial actions could include:

- re-export of the consignment; or
- destruction of the consignment; or
- treatment of the consignment and re-inspection to ensure that the pest risk has been addressed.

Separate to the corrective measures mentioned above, other remedial actions may be necessary depending on the specific pest intercepted and the risk management strategy put in place against that pest in the protocol. In the event that an uncategorised pest is detected, BAF will be asked to investigate the association of that pest with the commodity.

DAFF reserves the right to suspend the export program and conduct an audit of the risk management systems in Fiji. The program will recommence only after DAFF (in consultation with the relevant state departments if required) 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 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 Audit

DAFF will audit the phytosanitary procedures prior to trade commencing.

5.4 Review of policy

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.

DAFF will review the import policy after the first year of trade. This includes a review of the quarantine status of *Radopholus similis* - putative intraspecific ginger variant.

6 Conclusion

The findings of this final IRA report are based on a comprehensive analysis of relevant scientific literature. DAFF considers that the risk management measures and operational system for the maintenance and verification of phytosanitary status proposed in this 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. Distribution is restricted to the tropics, so potentially could establish in northern Australia. Feeds on a range of live and dead plant material in the field and in storage and trade, including avocado, lemon and sugarcane (Mau and Martin Kessing 1992a).	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). Particularly a storage pest of root crops such as taro and ginger.	**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
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 (Tenbrink *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 2012). 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 2012).	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] Burrowing nematode	Yes (Orton Williams 1980).	Yes – Ginger is a host of *Radopholus similis* (CABI 2012). *Radopholus* species are polyphagous 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
Radopholus similis (Cobb, 1893) Thorne 1949 – putative intraspecific ginger variant [Pratylenchidae] Burrowing nematode	Yes (Cobon *et al*. 2012 *in press*)	Yes – The nematode feeds on the outer parts of the rhizome (Turaganivalu *et al*. 2009).	No – Problems with *Radopholus similis* have never been observed on ginger in Queensland (Cobon *et al*. 2012 *in press*).	Yes - The nematode has limited capacity for natural spread, and it is mostly associated with the movement of infested plant material and accompanying soil (EPPO 1990; Turaganivalu *et al*. 2009).	Yes – This nematode is capable of killing ginger plants and destroying rhizomes (Turaganivalu *et al*. 2009).	Yes
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

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
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**
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 (biovar 4) Bacterial wilt of ginger	Not reported to be present in Fiji (Dingley *et al*. 1981; Stout 1982).	No – The bacterial wilt strain affecting ginger is not present in Fiji.	Yes – Bacterial wilt ginger biovar (IV) was introduced to south-eastern Queensland in 1954, causing heavy losses in an outbreak in 1965 and subsequent years (Pegg *et al*. 1974). Not currently a problem, but eradication has not been confirmed.			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
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 of ginger	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
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

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 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 (such as 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
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

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**
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
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 2012).	Yes – Recorded in Qld (Simmonds 1966) (as *Ascochyta phaseolorum* Sacc.), Tas. (Sampson and Walker 1982) and WA (Shivas 1989) (as *Phoma exigua*).			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
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
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

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
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* (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 2012), 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 Cook Islands.

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	***Radopholus similis* (Cobb, 1893) Thorne 1949 – putative ginger race**
Synonyms	
Common name(s)	Burrowing nematode
Main hosts	*Zingiber officinale* (Turaganivalu *et al*. 2009). Also reported from *Eluesine indica* and *Crassocephalum crepidoides* (Smith *et al*. 2007b).
Distribution	Fiji (Cobon *et al*. 2012 *in press*).

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	In Fiji, *Sphaeronema* sp. (or spp.) has been associated with citrus, *Hevea brasiliensis* (rubber tree), *Pandanus* sp. (screw pine), *Saccharum officinarum* (sugarcane), *Swietenia macrophylla* (big leaved mahogany), *Theobroma cacao* (cocoa) (Orton Williams 1980) and *Zingiber officinale* (Smith *et al.* 2007a). Hosts from other Pacific Island countries include *Ananas comosus* (pineapple), *Capsicum frutescens* (chilli), *Carica papaya* (pawpaw), *Cocos nucifera* (coconut), *Cucurbita maxima* (giant pumpkin), *Kleinhovia hospita* (guest tree), *Metroxylon solomonense* (ivory nut palm), *Musa sapientum* (sweet banana), *Nerium oleander* (common oleander), *Rhus taitensis* (tavai), *Schizostachyum glaucifolium* (Hawaiian bamboo) and *Terminalia catappa* (tropical almond) (Orton Williams 1980). A *Sphaeronema* sp. has been recorded on *Opuntia stricta* (prickly pear) in Australia (McLeod *et al*. 1994).
Distribution	*Sphaeronema* spp. are found in many countries and the genus has a wide geographical distribution. Little research has been done on cystoid nematodes in the Pacific, which remain unidentified at the species level. Within the Pacific region, nematodes identified as *Sphaeronema* sp. have been recorded in Fiji, Kiribati, Samoa, Tonga (Bridge 1988; Orton Williams 1980). It is unknown if this is one or many species. An unidentified *Sphaeronema* sp. has also been recorded in Australia (McLeod *et al*. 1994).

Appendix C Scientific issues raised in stakeholder comments

A summary of the major stakeholder issues and how they were considered in the provisional final report is given below.

Issue 1: AGIA and DAFF Queensland believe that the pest risk assessments need to be revised to account that significant soil will be attached to imported ginger. Many pests and diseases are carried in soil adhering to ginger rhizomes.

Australia has general requirements for all fruit and vegetables which require that consignments must be free of live insects, disease symptoms, trash, contaminant seeds, soil and other debris on arrival in Australia. The assessment of soil contamination is beyond the scope of this analysis as soil is prohibited by current policy.

Existing operational policies deal with soil contamination of fresh produce. Many other currently permitted root crops, bulbs and tubers, including garlic, onions, carrots, parsnips, yams and taro, are managed at the border by DAFF. Other articles such as passengers' clothes and shoes, luggage, containers, vehicles and machinery are also routinely managed to reduce the risk of soil. In addition, Australian ginger producers have access and have traded in markets under which imports are required to be free of soil, at both domestic and international level. Australia manages the risk of soil as a contaminant to a very low level but not zero. Where soil is detected in consignments remedial action is taken.

Amendments to the scope of the report now state this position more clearly.

Issue 2: Fresh ginger rhizomes are essentially planting material.

The IRA acknowledges that ginger rhizomes will be planted by consumers. The pest risk assessments have taken into account the potential for some rhizomes to be planted when determining the probabilities of distribution and establishment. The AGIA and DAFF Queensland submissions have also suggested that growers could import bulk consignments for planting purposes. This would be a contravention of the conditions on the import permit, and liable to prosecution.

Issue 3: The draft IRA does not take sufficient account of the wide and varied host ranges of particular pests and pathogens, and the genetic diversity of these organisms.

AGIA, DAFF Queensland and Growcom have contested the quarantine status of a number of pests that were not assessed further in the draft IRA due to their reported presence in Australia.

DAFF conducts its risk assessments in accordance with internationally agreed standards, including ISPM 11 (FAO 2004). According to ISPM 11:

> The taxonomic unit for the pest is generally species. The use of a higher or lower taxonomic level should be supported by scientifically sound rationale. In the case of levels below the species, this should include evidence demonstrating that factors such as differences in virulence, host range or vector relationships are significant enough to affect the phytosanitary status (FAO 2004).

In general DAFF relies on published peer reviewed literature and well established concepts to determine pest status.

However, with the exception of submissions on *Radopholus similis*, the evidence provided to DAFF has not been sufficient to support intraspecific variation consistent with the ISPM 11 definition. The submissions in general support the notion of genetic diversity as being evidence of pathogenicity differences. This view is not supported by DAFF. These issues are addressed further under the relevant points below.

Issue 4: AGIA believes that the draft IRA grossly underestimates the potential consequences for the natural environment.

The submission provided by AGIA claims that the draft IRA grossly underestimates the potential consequences for the natural environment. In supporting discussion AGIA goes on to agree with the DAFF assessment of consequences for yam scale, ring nematode, spiral nematode and made no comment on ginger weevil.

In the case of cystoid nematode AGIA provided revised consequence table ratings and supporting text. However the supporting arguments used in the *Direct - Other aspects of the environment* category are essentially direct plant effects which are dealt with under the category *Direct – Plant life or health*. The category *Direct - Other aspects of the environment*' considers the direct impacts on other aspects of the environment other than those on plants health, not direct plant effects. DAFF is not aware of any direct impacts caused by the assessed pests on other aspects of the environment that would justify giving a higher rating.

AGIA comments for cystoid nematode under the category *Indirect effects – Environmental and non-commercial* are speculative and do not take into account the lack of evidence within the nematode's current distribution, where there are available hosts and no evidence of significant effects on plant communities, environmentally sensitive areas, changes in ecological processes or ecosystem ability, effects on human use, or environmental restoration cost. Additional information has been added to the consequences table to provide clarity surrounding the issues raised above.

AGIA have also provided pest risk assessments and comments on consequences for *Rotylenchulus reniformis*, *Ralstonia solanacearum*, *Pythium graminicola* and *Pythium vexans*, *Fusarium oxysporum* f. sp. *zingiberi* and *Verticillium albo-atrum*. All of these species are present in Australia and do not meet the definition of quarantine pests. Despite their presence in Australia, there is no evidence of the dramatic environmental effects predicted in the AGIA submission. *Radopholus similis* is addressed under Issue 6.

The AGIA submission also includes an unpublished report by Jonathan Lidbetter titled 'Risks from imported fresh ginger to ginger relatives in the Australian native environment'. In relation to risk Lidbetter focuses on a short review of the myrtle rust incursion and refers to two diseases of ginger; both of which are already in Australia. Neither of the two ginger diseases has caused significant impact on the environment in Australia. Lidbetter provides a useful review of Zingiberales, but does not contribute any new information on exotic disease risks to the Zingiberales for the IRA.

Issue 5: AGIA and DAFF Queensland – DAFF should provide significantly more detailed information about ginger cultivation practises in Fiji. The draft IRA overstates efficacy of on-farm practices in reducing pest populations.

The unrestricted risk estimate makes few assumptions about the production practices involved. Steps such as hot water dipping do not guarantee the rhizomes will be pest free. As there are doubts about whether farmers are currently carrying out such practices reliably, the IRA does not assume that they will be carried out effectively 100 % of the time.

Information on ginger production is publicly available, for example MPI (2011) and Smith *et al*. (2012). The information provided in the IRA is a general overview as background to the risk analysis. Inclusion of specific details such as the locations of ginger farms, or the methods for hot water treatment of seed, are not necessary as these are not factors in the scope of the risk assessments. The Fiji market access submission does not propose to limit ginger exports to a particular area, or stipulate that hot water treatment is mandatory. So the assumption for the analysis is that all areas are under consideration whether hot water dipped or not.

Issue 6: AGIA believe that a risk assessment is required for *Radopholus similis.* The burrowing nematode, *Radopholus similis,* in Fiji is different to the species in Australia.

DAFF conducts its risk assessments in accordance with internationally agreed standards, including ISPM 11 (FAO 2004). According to ISPM 11:

> The taxonomic unit for the pest is generally species. The use of a higher or lower taxonomic level should be supported by scientifically sound rationale. In the case of levels below the species, this should include evidence demonstrating that factors such as differences in virulence, host range or vector relationships are significant enough to affect the phytosanitary status (FAO 2004).

In general, DAFF relies on published peer reviewed literature and well established concepts to determine pest status.

Pathogenicity

The submission from AGIA argues that the 'Fijian species of this nematode on ginger most likely would be different than the Australian species.' The primary evidence put forward by AGIA is supported by DAFF Queensland and comprises of studies conducted by, or in collaboration with, DAFF Queensland scientists: Turaganivalu *et al*. (2012); Smith *et al*. (2012); and an unpublished trial by Cobon *et al.* (2012 *in press*). A summary of the findings of each paper are provided below.

Turaganivalu *et al*. (2012):

- This study noted that *Radopholus similis* was observed to cause severe impact on ginger at some locations in Fiji.
- Severe impact was associated with poor seed preparation and continuous cropping practises.
- Where ginger was grown in rotation with cassava and taro, *Radopholus similis* levels in the crop declined to undetectable levels.
- Where hot water treatment of seed was practiced correctly, rhizomes were free of nematodes.
- The paper makes no comment on the comparative pathogenicity of Australian and Fijian isolates, or sub-species rank.
- On the contrary, the paper attributes the disease impact on poor crop practice.

Smith *et al.* (2012):

- This is the ACIAR project under which the study by Turaganivalu *et al*. (2012) was conducted. No relevant additional information is presented.
- The report makes no comment on the comparative pathogenicity of Australian and Fijian isolates, or discussion of potentially different sub-species.

Cobon *et al*. (2012 *in press*):

An updated version of this paper was supplied after the comment period in the form of an *in press* poster submission for the 7th Australasian Soilborne Diseases Symposium to be held in Fremantle, September 2012. The following comments refer to this latter version, which can be accessed along with other stakeholder submissions on the DAFF website:

- No positive control was included.
- Physical parameters (moisture, temperature) were not measured, or controlled.
- The study included only one isolate from Australia.
- No isolates from Fiji were included.
- The study shows that the Australian isolate hosted on ginger.
- The authors note that the results differ markedly from results described by Turaganivalu *et al*. (2012), which they claim was conducted under similar conditions.

There are significant deficiencies in the evidence provided in the AGIA and DAFF Queensland submissions. No rigorous scientific comparison of the pathogenicity of Fijian and Australian populations on ginger was conducted. The key piece of evidence Cobon *et al*. (2012 *in press*) was not structured to address the differences in pathogenicity due to; the lack of positive controls to verify the vigour of the isolate, the lack of isolate replication to provide a representative sample of the pathogen and the lack of comparative material from Fiji. However, the study is concerning due to the marked difference in pathogenicity reported in Fiji.

The AGIA view, as stated in its submission, that ginger is not a host of the Australian *Radopholus similis* isolate is clearly not supported by Cobon *et al*. (2012 *in press*).

DAFF requested additional clarification and information from DAFF Queensland in relation to the Cobon *et al*. (2012 *in press*) and Turaganivalu *et al*. (2012) papers. This new information confirmed the following:

- The two trials used different ginger varieties; white ginger by Turaganivalu *et al*. (2012) and Queensland ginger by Cobon *et al*. (2012 *in press*). For reliable comparison the same varieties should be used.
- The Cobon *et al*. (2012 *in press*) trial was subjected to a wider range of temperature (19 °C and 31 °C, with an average of 24 °C) than *Radopholus similis* in the Turaganivalu *et al*. (2012) trial (26 °C ± 3 °C).
- Soils used in the Cobon *et al*. (2012 *in press*) trial consisted of two parts washed river sand and one part peat moss (sterilized at 65 °C for 30 min) while the Turaganivalu *et al*. (2012) trial used two parts washed river sand and one part commercial potting mix (sterilized at 70 °C for 30 min).
- The *Radopholus similis* isolate used by Cobon *et al*. (2012 *in press*) was collected on banana at Pimpama (longitude 153.29891E, latitude 27.81565S), south of Brisbane while the isolate used by Turaganivalu *et al*. (2012) was collected on ginger from Veikoba, Fiji.
- DAFF Queensland have confirmed that the despite not including a positive control in Cobon *et al*. (2012 *in press*) the pathogenicity of the isolate has been separately confirmed in other trials run concurrent with the experiments on ginger.
- Raw data was provided from the trial conducted by Cobon *et al*. (2012 *in press*) provided by DAFF Queensland. Cobon *et al*. (2012 *in press*) concluded that

> ‘Inoculated and control plants showed no signs of disease at 16 and 20 weeks’ and that the nematode ‘did not produce above ground symptoms’. However, the data set provided by DAFF Queensland appears to show significant differences between the control and inoculated treatments in shoot length, wet weight and dry weight at 20 weeks.

Host status

The AGIA submission also claims that *Radopholus similis* is not found on banana in Fiji despite extensive survey adjacent to severely infested ginger blocks, citing Smith *et al*. (2012). Following the close of the submission period, DAFF Queensland provided additional evidence in the form of survey records from Fiji that indicate that the Fijian *Radopholus similis* population on ginger does not infect banana. The DAFF Queensland records show that a total of eight plants were surveyed adjacent to infested areas, at five farms, across two districts where *Radopholus similis* had been found on ginger. It is apparent that the claim that banana in Fiji has been extensively sampled is not supported.

Subsequent correspondence provided by DAFF Queensland indicates that DAFF Queensland scientists do not support the AGIA claim that banana is not a host, but instead that they believe that “the Fijian variant is highly pathogenic on ginger, while banana is a poor host (Mike Smith, Jenny Cobon, DAFF Queensland, *personal communication*).

Provisional pest status

Currently the only intraspecific variant of *Radopholus similis* regulated at the international level is the citrus infecting race/pathotype, which has a restricted distribution (Florida and Hawaii) and is not known from Fiji. Both the citrus and non-citrus hosting variants are known to cause disease on banana.

To address the uncertainty and lack of peer reviewed published information DAFF has sought independent advice on the likelihood of the claims made above. An independent assessment has indicated that it is highly likely that Australian and Fijian populations currently recognised as *Radopholus similis* are different biological entities with differing pathogenicity and perhaps host relationships (Mike Hodda, CSIRO, *personal communication*).

Article 5 of the SPS agreement states:

> In cases where relevant scientific evidence is insufficient, a Member may provisionally adopt sanitary or phytosanitary measures on the basis of the available pertinent information, including that from the relevant international organizations, as well as from sanitary or phytosanitary measures applied by other Members. In such circumstances, Members shall seek to obtain the additional information necessary for a more objective assessment or risk and review the sanitary or phytosanitary measure accordingly within a reasonable period of time.

On this basis the submissions of AGIA and DAFF Queensland on *Radopholus similis* have been provisionally accepted and a pest risk assessment on *Radopholus similis* - putative intraspecific ginger variant has been included in the IRA. This assessment is conducted as a new pest postulated to occur in Fiji only and does not alter existing DAFF policy for *Radopholus similis*.

Issue 7: AGIA and Growcom believe that a risk assessment is required for *Rotylenchulus reniformis.* The reniform nematode, *Rotylenchulus reniformis,* has a restricted

distribution in Australia. Southeast Queensland should be officially identified as an endangered area, as defined in ISPM 5, and *Rotylenchulus reniformis* considered as a quarantine pest accordingly.

For a pest to qualify as a quarantine pest, as defined in ISPM 5, it must be 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 2012). The concept of official control is defined as 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 2012).

Rotylenchulus reniformis is present in the endangered area (Australia) and is not restricted in its distribution, but is widely distributed within Queensland and other states. There are no mandatory phytosanitary regulations, or application of mandatory phytosanitary procedures with the objective of eradication or containment of this pest. *Rotylenchulus reniformis* does not meet the definition of a pest which is 'present but not widely distributed and being officially controlled'.

Issue 8: AGIA believe that a risk assessment is required for *Ralstonia solanacearum*. There is a significant risk that a strain of bacterial wilt, *Ralstonia solanacearum*, potentially pathogenic to Australian ginger is present in Fiji.

The AGIA submission has requested that a pest risk assessment be conducted on *Ralstonia solanacearum*. However this pathogen is not reported from Fiji.

Ginger has been grown in Fiji since the late nineteenth century. If a significantly pathogenic strain was present, it is highly likely that it would have been identified by now. A number of surveys for plant pathogens have been conducted in Fiji and bacterial wilt of ginger has not been detected. Any incursion of the pathogen into the ginger cropping areas since those surveys would likely be detected, as the climate in Fiji is ideal for disease development.

Issue 9: AGIA believe that a risk assessment is required for *Pythium graminicola* and *Pythium vexans*. There is strong evidence that Fiji has strains of *Pythium graminicola* and *Pythium vexans* that are more pathogenic than those in Australia.

DAFF conducts its risk assessments in accordance with internationally agreed standards, including ISPM 11 (FAO 2004). According to ISPM 11:

> The taxonomic unit for the pest is generally species. The use of a higher or lower taxonomic level should be supported by scientifically sound rationale. In the case of levels below the species, this should include evidence demonstrating that factors such as differences in virulence, host range or vector relationships are significant enough to affect the phytosanitary status (FAO 2004).

In general, DAFF relies on published peer reviewed literature and well established concepts to determine pest status.

Pythium graminicola

In the case of *Pythium graminicola*, no scientific evidence was provided to support the claim. DAFF considers that the AGIA claim that *Pythium graminicola* from Fiji is more pathogenic than *Pythium graminicola* in Australia has no basis. DAFF has therefore rejected this claim.

Pythium vexans

In the case of *Pythium vexans*, AGIA claims to have strong evidence that the Fijian populations differ from Australian populations in the form of an unpublished paper by PD Le. The paper by Le (unpublished) may be summarised as follows:

- This study noted that a *Pythium vexans* isolate from Australia was more aggressive in colonising ginger pieces than an isolate from Fiji.
- This study included compared one isolate each from Australia and Fiji.
- The study was not a pathogenicity study but instead measured aggressiveness of the two isolates on ginger pieces.
- The study did not attempt to measure pathogenicity variability within and between Australian and Fijian populations. Hence no inference on differences in pathogenicity between Australian and Fijian populations is possible.
- Le made no comment on the relative pathogenicity of the Fijian isolate or sub-species rank.

The evidence provided by AGIA is not of a standard that would support with any scientific rigor that fixed population difference in host status or pathogenicity on ginger between Australian and Fijian population exist.

The DAFF position on *Pythium vexans,* which was stated in the draft IRA report, is that this pathogen is already present in Australia. In order to meet the definition of a quarantine pest it must be absent from the area of risk, or present but under official control. As this species is present and there are no interstate restrictions on the movement of this species, it does not meet the definition of a quarantine pest.

Issue 10: AGIA and DAFF Queensland believe that a risk assessment is required for *Fusarium oxysporum* f.sp. *zingiberi.* Isolates of *Fusarium oxysporum* f.sp. *zingiberi* are very likely to be more pathogenic than Australian isolates.

DAFF conducts its risk assessments in accordance with internationally agreed standards, including ISPM 11 (FAO 2004). According to ISPM 11:

> The taxonomic unit for the pest is generally species. The use of a higher or lower taxonomic level should be supported by scientifically sound rationale. In the case of levels below the species, this should include evidence demonstrating that factors such as differences in virulence, host range or vector relationships are significant enough to affect the phytosanitary status (FAO 2004).

In general, DAFF relies on published peer reviewed literature and well established concepts to determine pest status.

There is no scientific evidence to substantiate the claim that Australian populations of *Fusarium oxysporum* f.sp. *zingiberi* are significantly different in pathogenicity to those from Fiji. DAFF Queensland and AGIA have cited the study of Pappalardo *et al*. (2009) in support of this claim. The findings of Pappalardo *et al*. may be summarised as follows:

- The study consisted of analysis of genetic diversity, not pathogenicity.
- Two groups were identified with very little evidence of genetic variation. These were designated Foz Groups 1 and 2.
- A single isolate was found to be divergent from Foz Groups 1 and 2.

- The authors made no inference as to the relative pathogenicity of these two groups, or the divergent isolate.
- The authors did speculate that the divergent isolate may be a new introduction or an emerging pathotype.
- All *Fusarium oxysporum* f.sp. *zingiberi* studied belonged to a single vegetative compatibility group VGC 0460.
- The study consisted of entirely Australian isolates. The author did not make any conclusions regarding pathogenicity differences.

The speculation that 'there is a possibility of more pathogenic isolates existing in Fiji' cannot be substantiated from the information in the article by Pappalardo *et.al*. (2009). Other references cited in the AGIA submission relate to other *forma specialis* of *Fusarium oxysporum*. The conclusions drawn from these articles by the AGIA submission are speculative and are not addressed further here.

Issue 11: AGIA believes that a risk assessment is required for *Verticillium albo-atrum*. Some historical records of *Verticillium albo-atrum* in Australia are really *Verticillium dahliae*, so a risk assessment should be done for potential impacts on other crops in Australia.

While some historical Australian records may be misidentifications, other records have been confirmed. Since the pathogen is known to be present in Australia and the movement of ginger and other hosts within Australia do not attract phytosanitary restrictions, DAFF does not consider this to be a quarantine pest.

Issue 12: DAFF Queensland is concerned that comments previously provided on the draft pest categorisation table have not been appropriately considered in the draft IRA. DAFF Queensland wishes to reassert that these comments remain valid.

All comments on pest categorisation were considered during preparation of the draft report. However, a number of the claims from DAFF Queensland were scientifically unsubstantiated, or factually incorrect, and could not be considered further. Comments on two pests, *Fusarium oxysporum* f.sp. *zingiberi* and *Radopholus similis* are already addressed above. Further comments the DAFF categorisation table submission not addressed above are discussed below.

Issue 13: DAFF Queensland believes that a risk assessment is required for *Pythium myriotylum*. *Pythium myriotylum* is present in Australia but this species/isolate may be different than the Fijian species/isolate. Stirling *et al.* (2009) believe that the Fijian species is more virulent and damaging to ginger than the Australian species.

The DAFF position on this species is that this pathogen is already present in Australia. In order to meet the definition of a quarantine pest it must be absent from the area of risk, or present but under official control. As this species is present and there are no interstate restrictions on the movement of this species it does not meet the definition of a quarantine pest. DAFF Queensland requested that the species from Fiji be considered a different strain. DAFF Queensland has provided a single reference in support of this claim (Stirling *et al*. 2009).

DAFF conducts its risk assessments in accordance with internationally agreed standards, including ISPM 11 (FAO 2004). According to ISPM 11:

> The taxonomic unit for the pest is generally species. The use of a higher or lower taxonomic level should be supported by scientifically sound rationale. In the case of levels below the species, this should include evidence demonstrating that factors such as differences in virulence, host range or vector relationships are significant enough to affect the phytosanitary status (FAO 2004).

In general, DAFF relies on published peer reviewed literature and well established concepts to determine pest status.

DAFF has reviewed the information contained within Stirling *et al*. (2009) and concluded that it does not provide support for the claim that there are significant differences between Australian and Fijian isolates. The following points are provided to support this conclusion:

- The study indicated that all four species used in the pathogenicity studies (two from Fiji and two from Australia) had identical ITS sequences with the CBS reference culture that was used in the original description of *Pythium myriotylum*. The authors concluded from this that the isolates were identical and that they were the same species: *Pythium myriotylum*.
- DAFF Queensland noted that there was variability in cultural characteristics of Fijian isolates. However, the authors specifically state that pathogenicity tests were not undertaken to investigate this further. Cultural variability alone is not evidence of variability in pathogenicity.
- One Australian isolate was identified that differed in ITS sequence from those used in the pathogenicity tests. No inference was made that this isolate differed in pathogenicity from the others.
- Within pathogenicity tests, no significant intra-specific variation between isolates was detected.
- DAFF was unable to find any evidence in the paper to support the statement 'the authors also believe that the Fijian species is more virulent and damaging to ginger than the Australian species.' The authors' own conclusions were that the threat to Fijian ginger production was exacerbated by 'the ideal moisture and temperature conditions', 'soils which are continually saturated from constant rain' and the 'expense of chemical and cultural methods of control.' They concluded that within 'Australia it may not be worth developing management practices for rhizome rot as the disease is only likely to occur sporadically in years of exceptionally high rainfall'.
- The differences in environmental conditions seem sufficient to explain any difference in field impacts between Australia and Fiji without invoking pathogen variability. The authors do not attribute the observed differences to pathogenicity differences.

DAFF has also been unable to find any additional information that would support the DAFF Queensland assertions. The DAFF Queensland submission on the draft categorisation table has been added to the public file for transparency.

Issue 14: DAFF Queensland believes that a risk assessment is required for *Aspidiella sacchari.* 'Rhizome infestation by *Aspidiella sacchari* is reported in both field and storage conditions (Devasahayam and Abdulla Koya 2005) and a photo of an infested rhizome can be viewed in the report prepared by the Australian ginger industry (Hutchings

2010). Based on the information, DEEDI believes that risk assessment for *Aspidiella sacchari* is required.'[sic]

This species was considered, but was determined to not be on the ginger rhizome pathway in the draft IRA. The DAFF Queensland submission contains citation errors. Devasahayam and Abdulla Koya (2005) refer to *Aspidiella hartii* as a pest of ginger, not *Aspidiella sacchari*. *Aspidiella sacchari* is not mentioned in this particular reference. The photo of an infested rhizome in Hutchings (2010) is identified only as 'rhizome scale', and is likely to be *Aspidiella hartii*. Ginger is not known as a host of *Aspidiella sacchari*, and there are no grounds to justify undertaking a full pest risk assessment. A full pest risk assessment for *Aspidiella hartii* is included in the draft IRA document.

Issue 15: DAFF Queensland believes that a risk assessment is required for *Adoretus versutus.* 'The pest categorisation table says that rose beetle, *Adoretus versutus*, is unlikely to be present on rhizomes, yet states that larvae may feed on roots of host plants. In the literature, rhizomes are known as one kind of storage root. Therefore, DEEDI believes that *Adoretus versutus* is capable of infecting ginger rhizomes entering Australia unless there is a proper risk assessment for this pest.' [sic]

Rose beetle is not known as a storage pest of ginger or other root crops. The larvae are free-living in the soil and feed on organic material within the soil, including living plant roots (Waterhouse and Norris 1987). This could potentially include roots of ginger plants. However, there is no specific known association of rose beetle with ginger rhizomes, no reports of larvae being found inside rhizomes, and no history of interceptions in trade. The literature makes no reference to larvae feeding inside living plant tissue, so it is considered unlikely that grubs would be present inside ginger rhizomes that potentially could escape detection during harvest and at the packing house. Any larvae feeding in the rhizosphere would be excluded from the pathway by the removal of soil and roots from rhizomes prior to export.

Amendments in the provisional final report

Following stakeholder consultation on the draft IRA report, a number of amendments were made in the provisional final report. The significant changes are outlined below.

- Additional information has been added to clarify the scope of the report.
- Further text has been added to the scope and phytosanitary measures in relation to soil contamination.
- The text in Chapter 3 has been revised with some additional references added and clarification provided on the purpose of the 2007 trip report.
- An additional pest risk assessment has been included for a putative intraspecific ginger variant of burrowing nematode, *Radopholus similis*. This pest has been assessed to have an unrestricted risk estimate of ‘low’, and therefore additional measures have been proposed in Chapter 5.
- For Fiji ginger weevil, *Elytroteinus subtruncatus*, the rating for probability of distribution has been raised from ‘moderate’ to ‘high’. More detailed information was included on host records for this species and its association with host plants. The resulting unrestricted risk estimate remains at ‘negligible’, and does not require application of additional measures.
- For yam scale, *Aspidiella hartii*, the rating for probability of establishment has been raised from ‘moderate’ to ‘high’ as provided information suggests that the scale may be able to reproduce parthenogenetically. In the consequences table, the rating for impacts on ‘Other aspects of the environment’ was lowered from B to A as there are no reported direct impacts on non-plant health related aspects of the environment. The resulting unrestricted risk estimate remains at ‘low’, and therefore still requires the application of additional measures.
- For ring nematodes, the rating in the consequences table for indirect environmental or non-commercial impacts was raised from A to B, as other ring nematode species are associated with damage to turfgrass roots, affecting the amenity of facilities such as golf courses. The unrestricted risk estimate remains at ‘negligible’, and does not require application of additional measures.
- For all quarantine pests assessed in the report, additional text has been added to the consequences tables to clarify the difference between direct and indirect consequences and justify the determined ratings for potential environmental impacts.
- The garden soldier fly, *Exaireta spinigera*, has been deleted from the pest categorisation table, as its inclusion was based on a suspect interception record.

Appendix D 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.

[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 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 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 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 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:

- 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 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'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'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 2011*.

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 2012).
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 2012).
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 2012).
Certificate	An official document which attests to the phytosanitary status of any consignment affected by phytosanitary regulations (FAO 2012).
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 2012).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2012).
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 2012).
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 2012).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2012).
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2012).
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2012).
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2012).
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 2012).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used (FAO 2012).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2012).
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 2012).
Introduction	The entry of a pest resulting in its establishment (FAO 2012).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin and so forth, forming part of a consignment (FAO 2012).
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2012).
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 2012).
Pathway	Any means that allows the entry or spread of a pest (FAO 2012).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2012).

Term or abbreviation	Definition
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 2012).
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 2012).
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 2012).
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 2012).
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 2012).
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 2012).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2012).
Phytosanitary certificate	Certificate patterned after the model certificates of the IPPC (FAO 2012).
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 2012).
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 2012).
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 2012).
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 2012).
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 2012).
Restricted risk	Risk estimate with phytosanitary measure(s) applied.
Spread	Expansion of the geographical distribution of a pest within an area (FAO 2012).
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 2012).
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk mitigation measures.

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