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Import risk analysis: ginger (*Zingiber officinale*, *Zingiber zerumbet*) fresh produce

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New Zealand is a member of the World Trade Organisation and a signatory to the Agreement on the Application of Sanitary and Phytosanitary Measures ("The Agreement"). Under the Agreement, countries must base their measures on an International Standard or an assessment of the biological risks to plant, animal or human health.

This document provides a scientific analysis of the risks associated with the importation of *Zingiber officinale* and *Z. zerumbet* fresh produce (rhizomes) from Australia, China, Fiji, Nuie, Papua New Guinea, Samoa, Thailand, Tonga and Vanuatu. It assesses the likelihood of entry, exposure, establishment and spread of pest organisms associated with *Zingiber officinale* and *Z. zerumbet* fresh produce imported from the aforementioned countries, and assesses the potential impacts of those organisms should they enter and establish in New Zealand. The document has been internally and externally peer reviewed and is now released publically. Any significant new science information received that may alter the level of assessed risk will be included in a review, and an updated version released.

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Contents

Page

Tables

Page

Executive summary

Background

This risk analysis has been developed in response to a request to review the Import Health Standards (IHSs) for *Zingiber officinale* and *Z. zerumbet* fresh produce from Australia, Fiji, Nuie, Papua New Guinea, Samoa, Thailand, Tonga and Vanuatu, to develop a new IHS for *Zingiber officinale* and *Z. zerumbet* fresh produce from China, and to consolidate these standards into a single IHS for *Zingiber officinale* and *Z. zerumbet* fresh produce from all of these countries.

Objectives

MPI's objectives in developing a new IHS for *Zingiber officinale* and *Z. zerumbet* fresh produce are to determine which pathogens, invertebrates and nematodes are:

(a) associated with *Zingiber officinale* and *Z. zerumbet* fresh produce, and
(b) meet the risk evaluation criteria for additional measures beyond the minimum measures proposed for the Import Health Standard,

in order to ensure that the known biosecurity risk from regulated organisms associated with imported *Zingiber officinale* and *Z. zerumbet* fresh produce is managed appropriately.

Scope

This risk analysis considers the effects on the New Zealand economy, environment and society, as well as human health, from pathogens and nematodes potentially associated with the importation of *Zingiber officinale* and *Z. zerumbet* fresh produce from Australia, China, Fiji, Nuie, Papua New Guinea, Samoa, Thailand, Tonga and Vanuatu.

Methodology

Pathogens, invertebrates and nematodes likely to be associated with *Zingiber officinale* and *Z. zerumbet* were identified using literature and database searches, including MPI's Emerging Risk System. Over 330 bacterial, fungal, nematode, oomycete, invertebrate and virus species (or higher-level taxa) were considered. These organisms were classed as hazards if they:

a) met the criteria to be a quarantine pest for New Zealand, and
b) were likely to be present on the importation pathway.

Species (or higher-level taxa such as genera) considered to be hazards were then assessed to determine whether they met the specific criteria for additional measures on *Zingiber officinale* and *Z. zerumbet* fresh produce. The specific criteria considered were:

a) the likelihood of the pest being detected during border inspection,
b) the likelihood of establishment of the pest in New Zealand, and
c) the likely level of impact of the pest if it established in New Zealand.

Results

As a result of these assessments, the following organisms either met the criteria for additional measures, or required further consideration in the risk management proposal for whether additional measures should be applied, given the uncertainty.

Bacteria: *Pantoea ananatis*

Nematodes: *Pratylenchus zeae*

Uncertainty

Ginger is a tropical and subtropical crop, and many of the pests associated with it are largely, or entirely, tropical or subtropical in distribution. For some of these organisms it is uncertain if they could establish in New Zealand, and if so how widely they could be distributed and what impacts they could have. The resulting uncertainty is reflected in the conclusions of the assessments.

1 Risk analysis background and process

1.1 Background

This import risk analysis (IRA) has been developed in response to a request to review the Import Health Standards (IHSs) for *Zingiber officinale* and *Z. zerumbet* fresh produce (rhizomes) from individual countries and consolidate them into a single IHS for all approved countries. MPI's objective in developing an import health standard for *Zingiber officinale* and *Z. zerumbet* fresh produce is to:

- ensure that the known biosecurity risk from regulated pests associated with imported *Zingiber officinale* and *Z. zerumbet* fresh produce is managed appropriately.

The purpose of the IRA is to identify and assess hazards[1] associated with the commodity, to inform decisions on risk management. The decision that this IRA will inform is:

1. Whether to require additional measures for any pests or pathogens.

The objective of the IRA is therefore to:

1. identify pests and pathogens which are associated with the commodity and may require additional measures
2. assess those pests and pathogens using a method which provides sufficient evidence about the biosecurity risks for a robust and transparent decision on whether to apply additional measures.

For particular types of risk goods, there are existing minimum requirements in IHSs which apply to all commodities which come under that particular type of risk good. The minimum requirements manage the risks of a wide range of organisms, regardless of whether those organisms are named in a pest list. The minimum requirements also mean that risk assessments and IHSs are robust in the face of many emerging and unknown risks.

Minimum risk management requirements for commodities are proposed during the planning phase of the IHS development process, prior to the development of the IRA. The minimum requirements are based on the risks of a particular commodity class (e.g. fresh produce) and existing policy for similar commodities.

In the case of *Zingiber officinale* and *Z. zerumbet* fresh produce, the information considered when identifying the minimum requirements is summarised in Table 1.

Table 1. Information for considering minimum requirements

Commodity class	Fresh produce is a medium-to-low risk commodity class overall[2]. This is because some or many of the pests associated with a particular plant species may not be associated the plant part imported, and because the intended use of fresh produce is human consumption, reducing the likelihood of exposure of associated pests to hosts in the environment of the importing county. Pests requiring vector transmission or propagation of the commodity, such as viruses, are very low risk on fresh produce. The level of risk of fresh produce will be affected by

1 Quarantine pests under IPPC
2 ISPM 32 https://www.ippc.int/static/media/files/publication/en/2016/01/ISPM_32_2009_En_2015-12-22_PostCPM10_InkAmReformatted.pdf

	the degree of processing (e.g. grading, sorting, washing, brushing etc.) of the commodity prior to export, and the amount of waste (uneaten) material generated by the commodity.
Commodity type	Rhizomes are likely to be in the middle-to-higher-end of the scale for relative risks associated with fresh produce. Discarded whole rhizomes (or large pieces of them) may be propagable, but generally most of the commodity will be consumed. A limited number of primary pests is likely to be associated with rhizomes, but incidental pests could be harboured in any soil attached to the commodity. Stored product pests and post-harvest rots may be associated with rhizomes, but these are likely to be visually detectable. The level of risk of rhizomes will be affected by the degree of processing (e.g. grading, sorting, washing, brushing etc.) of the commodity prior to export, and the amount of waste (uneaten) material generated by the commodity.
Commodity species and related species	Ginger (*Zingiber* spp.) is a tropical or subtropical crop and is not grown commercially in New Zealand. No species of *Zingiber* is grown ornamentally in New Zealand. The family to which *Zingiber* belongs, Zingiberaceae, has no New Zealand native representatives. Two exotic members of the family, *Hedychium gardnerianum* (kahili ginger) (though recent research suggests the New Zealand material of this "species" is a hybrid between *H. gardnerianum* and most likely *H. coronarium* (white ginger)) and *H. flavescens* (yellow ginger) are naturalised in New Zealand and considered serious weeds. A number of other species in the family are grown as ornamental plants (see Table 4, Section 2.4), and therefore have some commercial value in the nursery industry. A serious pest or pathogen for a particular species is more likely to come from host plants in the same genus or family than from host plants which are less related.

1.2 Scope of this risk analysis

This risk analysis considers the effects on the New Zealand economy, environment and society, as well as human health, from organisms potentially associated with the importation of *Zingiber officinale* and *Z. zerumbet* fresh produce (rhizomes) from Australia, China, Fiji, Nuie, Papua New Guinea, Samoa, Thailand, Tonga and Vanuatu[3].

Based on the previous minimum requirements and the general risk of the commodity type summarised in Table 1, the following minimum requirements *Zingiber officinale* and *Z. zerumbet* fresh produce are proposed in the risk management proposal (RMP) and draft IHS:

Fresh ginger for consumption will:

a) be free from viable regulated pests, soil and other contaminants;

3 Specifically, this IRA covers sections 23(4)(b)(i), (ii) and (iii) of the Biosecurity Act:
(i) the likelihood that the goods will import organisms:
(ii) the nature of the organisms that the goods may import:
(iii) the possible effect on human health, the New Zealand environment, and the New Zealand economy of the organisms that the goods may import

b) be commercially produced export quality fresh ginger. Export quality fresh ginger must have intact skin, be sound and free of rot, be free of signs of shrivelling and dehydration, and be free of abnormal moisture. Export quality fresh ginger must be able to withstand transportation and handling and must arrive in New Zealand in a satisfactory condition;
c) be substantially free from damage, bruising and defects;
d) be packaged in clean and either new or refurbished material;
e) be shipped in a secure manner to prevent contamination by regulated pests; and
f) be accompanied by documentation that meets the requirements of Part 3 *Inspection, Verification and Documentation Requirements* of the Import Health Standard.

Fresh ginger must not include flowers, leaves or any other plant parts. Zingiber officinale must not include roots.

Fresh ginger must only be used for human consumption

Fresh ginger must be sourced from a production site that uses standard commercial cultivation methods that comply with the principles of Good Agricultural Practice (GAP) including pest-control, harvesting, sorting, cleaning, inspection and packaging.

The NPPO of the exporting country must:

a) sample each homogeneous grower lot of fresh ginger. The minimum sample size for inspection must be based on a 95% confidence level that not more than 0.5% of the units in the lot are infested as set out in **ISPM 31.** *Methodologies for sampling of consignments Appendix 2*.

b) sample and visually inspect each sample unit according to official procedures in accordance with **ISPM 23.** *Guidelines for inspection* and **ISPM 31.** Methodologies for sampling of consignments for all regulated pests required by New Zealand.

In order to ensure that the risk analysis provides sufficient evidence for a robust and transparent decision in a timely manner, it needs to be focused on assessing the risk according to the specific risk management question and risk evaluation criteria[4] agreed on during the commissioning process (section 1.3.1).

The risk management question for the risk analysis is:

- **Which pests are associated with *Zingiber officinale* and *Z. zerumbet* fresh produce and meet the risk evaluation criteria for requiring additional measures (over the minimum requirements proposed in the RMP)?**

Pests which meet the risk evaluation criteria are those which are unlikely to be removed from the rhizomes by post-harvest processing (to produce clean, undamaged rhizomes) or be detected by inspection at the border. The risk assessment considers the likelihood of the pests being removed or detected and the risk if they are not.

4 The term “risk evaluation criteria” is not used in the IPPC context, but establishing risk evaluation criteria is a routine part of context setting in most risk management frameworks. For example there is a good explanation of risk evaluation criteria on page 7 of the linked document here. http://www.safedor.org/resources/SAFEDOR-D-04.05.02-2005-10-21-DNV-RiskEvaluationCriteria-rev-3.pdf

The pests that the risk management question applies to are pathogens (viruses, viroids, bacteria, fungi and oomycetes) invertebrates and nematodes.

1.3 The risk analysis process

The MPI framework for undertaking a risk analysis builds on the existing international framework of the International Plant Protection Convention (IPPC), and extends the scope under the SPS Agreement[5] to include all of the values required by the Biosecurity Act (1993)[6].
The following sections briefly describe the New Zealand Ministry for Primary Industries process and methodology for undertaking import risk analyses.

Table 2. The basic process of import risk assessment

<table>
<tr><td colspan="2" rowspan="2">Commissioning</td><td colspan="4">Drafting</td><td rowspan="2">Signoff and closeout</td></tr>
<tr><td>Hazard identification</td><td>Risk assessment</td><td>(Risk management options[7])</td><td>Reviewing</td></tr>
<tr><td>Approval to start</td><td>Plan the project</td><td colspan="4">Manage the project</td><td>Closeout</td></tr>
</table>

The MPI process is equivalent to the process for plant health risk analysis under the International Standards for Phytosanitary Measures (ISPM) under the International Plant Protection Convention (IPPC)[8]. The main difference is in terminology. However there is a more defined method for the commissioning stage. The most important aspects of this process are:

- The formulation of the risk management question is an essential part of initiating or commissioning a risk analysis.[9]
- The risk management question is formulated based on the minimum risk management requirements for that commodity type, according to existing policy.
- Risk evaluation criteria are based on the risk management question, so that the risk assessment directly addresses the specific questions of the risk manager and the conclusions are clear to readers.

1.3.1 Commissioning (Scoping and planning)

The process for scoping and planning a risk analysis is known as commissioning. During this process, important information is gathered, shared and dicussed, and decisions are made

5 SPS Agreement means the World Trade Organisation Agreement on the Application of Sanitary and Phytosanitary Measures
6 Biosecurity Act section sections 23(4)(b)(iii)…human health, the New Zealand environment, and the New Zealand economy. In addition, environment includes (a) ecosystems and their constituent parts, including people and their communities; and (b) all natural and physical resources; and (c) amenity values; and (d) the aesthetic, cultural, economic, and social conditions that affect or are affected by any matter referred to in paragraphs (a) to (c)
7 How this step is done depends on the risk management question. In most cases, only a single option is considered – the least trade resitrictive option for the commodity type, and that option evaluation is incorporated into the hazard ID and RA process rather than a separate step.
8 ISPM 2: Framework for Pest Risk Analysis
https://www.ippc.int/static/media/files/publication/en/2019/05/ISPM_02_2007_En_Framework_PRA_2019-04-30_PostCPM14_InkAm.pdf and ISPM 11: Pest Risk Analysis for Quarantine Pests
https://www.ippc.int/static/media/files/publication/en/2019/05/ISPM_11_2013_En_PRA_QPs_2019-04-30_PostCPM14_InkAm.pdf
9 Refer to FAO Biosecurity Toolkit http://www.fao.org/3/a1140e/a1140e.pdf eg P73.

about what will be assessed and how the assessment will be done. The kinds of information covered in the commissioning process include:

- the current context for the work e.g. new measures or a review of existing measures
- why the work is important
- stakeholders and interested parties (the process may include meetings with and gathering information from key stakeholders)
- the commodity description (i.e. the plant species, the exact parts of the the plant and the countries under consideration)
- the risk management question or questions
- criteria against which to assess the each hazard (and answer the risk management questions)
- general/ minimum requirements for the commodity class and proposed for the specific IHS
- the analytical approach including the hazard groups to be considered[10] and the likely level of detail
- the expected timelines.

The outcome of the commissioning process is a signed off plan for the IRA. The plan outlines how the work will be done and also includes supporting information, which gives the reasoning behind some of the main decisions about the IRA, such as the scope and analytical approach used. The plan for this IRA is included in Appendix 2.

The commodity and pathway information provides context for the hazard identification and risk assessment.

1.3.2 Hazard identification

Hazard identification is the process for identifying pests and pathogens associated with imported risk goods and which have the ability to cause harm to New Zealand. The process consists of compiling a list of potential hazards and then assessing them against criteria to see whether they warrant further consideration. The hazard identification answers the risk management questions:

- does the species meet the criteria to be considered a quarantine pest for New Zealand?
- is the species associated with the commodity which is being assessed?

The criteria for a quarantine pest for New Zealand are derived from the Biosecurity Act and ISPMs 2, 5 and 11. These criteria are:

- Is the species absent from New Zealand?
- **OR** Is the species present in New Zealand but meets one of following criteria?
    - The species is under official control

10 For a review of an IHS, it is not necessary to consider all groups of pests – it may be necessary to only consider some of the associated hazard groups. However for a new IHS, all groups of hazards must be considered, even if they are not assessed in any detail.

  - The species is a vector of quarantine pests
  - There are subspecific taxa (subspecies, varieties, strains etc) within the species which are an increased risk to New Zealand compared to those already present
  - There are other factors which would mean that the species may still be of concern in associated with imported goods (e.g. increased exposure to people through imported goods[11])

- **AND** Does the species have the potential to establish in New Zealand and harm "*human health, the New Zealand environment, and the New Zealand economy* [12]"

Association with the commodity is based on:

- association with the host species or genus
- association with the specific parts of the plant
- whether a particular pest will stay associated with a commodity when it is being handled – for example a large, flying insect is unlikely to stay on a piece of fruit when it is picked.

Under the IPPC, the hazard identification process is known as pest categorisation in ISPM 2 and ISPM 11.

Different approaches are taken to compiling the list of potential hazards depending on the information needed for each pest in those groups. The approach for each group of organisms is determined during the commissioning process, once the risk management question and risk evaluation criteria have been established. The approaches to be used are documented in the plan. The specific approaches to hazard identification used in this import risk analysis are discussed further in section 3.

1.3.3 Risk assessment

At the end of hazard identification, the list of hazards which require risk assessment is discussed and agreed on by the project team.

A risk assessment evaluates the likelihood of introduction and consequence for a particular hazard, as well as the uncertainty in the conclusions. The SPS agreement describes the factors to take into account when assessing risk. These factors include:

- available scientific evidence;
- relevant processes and production methods;
- relevant inspection, sampling and testing methods;
- prevalence of specific diseases or pests
- relevant ecological and environmental conditions.
- potential damage in the event of the entry, establishment or spread of a pest

11 One example is venomous spiders on fresh fruit. Even if present in a country, there may be a higher likelihood of people getting bitten if the spiders are associated with fruit sold at a supermarket.
12 Biosecurity Act 1993

The assessments have been structured using the CASE schema, which is a tool for presenting logical reasoning to make the arguments clearer to the reader.[13]
The approach to pest risk assessment used in this IRA is discussed further in Section 4.

1.3.4 Assessment of uncertainties

The SPS agreement states that measures must be applied *only to the extent necessary* and must be supported by *sufficient scientific evidence*[14]. Therefore, if there is insufficient evidence indicating that a hazard meets the criteria for requiring additional measures (the risk evaluation criteria), the hazard would not be considered further during decision-making (see section 1.3.5). However if there is insufficient evidence but significant uncertainty, then measures may be applied, but under those circumstances the measures are provisional and certain conditions must then be met[15].

Therefore documenting significant uncertainty is an essential part of a risk assessment. Uncertainties such as contradictions in the evidence or a lack of evidence are documented in the text. Where the risk assessment identifies significant uncertainty affecting the conclusion, this is indicated in the wording of the conclusion. The Risk Management Proposal (see section 1.3.5) gives further consideration to these risk assessments. See chapter 4 for further information on how uncertainty is documented.

1.3.5 How the risk analysis informs risk management decisions

The conclusions of the risk assessments are used to develop a Risk Management Proposal and the IHS. Specifically, the Risk Management Proposal considers additional measures for those hazards which meet the criteria as well as those where the conclusion had significant uncertainty. The Risk Management Proposal gives a rationale for the risk management decisions based on the assessments with significant uncertainty.

1.3.6 Review and consultation

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

The conclusions of the risk analysis are summarised in a risk management proposal that accompanies the draft IHS being consulted on. The risk analysis provides additional technical detail should submitters wish to see a more detailed scientific analysis of the biological risks.

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13 The CASE schema is based on presenting a **Contention** (the conclusion of the risk assessment) supported by **Arguments**, **Evidence** and **Sources**. Further information can be found at the following link: https://timvangelder.com/2019/04/07/what-is-the-case-schema/
14 Article 2.2 "Members shall ensure that any sanitary or phytosanitary measure is applied only to the extent necessary to protect human, animal or plant life or health, is based on scientific principles and is not maintained without sufficient scientific evidence, except as provided for in paragraph 7 of Article 5."
15 Article 5.7 "In cases where relevant scientific evidence is insufficient, a Member may provisionally adopt sanitary or phytosanitary measures on the basis of 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 of risk and review the sanitary or phytosanitary measure accordingly within a reasonable period of time."16 Nomenclature, including common names, as well as the wild status in New Zealand, is from Landcare Research (2019)

All submissions received from stakeholders will be analysed and compiled into a review of submissions. The Risk Analysis, Risk Management Proposal and draft Import Health Standards will be modified where appropriate depending on the outcome of consultation.

1.4 References for Chapter 1

FAO (1995) *International Standards for Phytosanitary Measures (ISPM) No. 2. Guidelines for pest risk analysis*. Secretariat of the International Plant Protection Convention, Food and Agricultural Organization of the United Nations, Rome.

FAO (2013) *International Standards for Phytosanitary Measures (ISPM) No. 11. Pest risk analysis for quarantine pests.* Secretariat of the International Plant Protection Convention, Food and Agricultural Organization of the United Nations, Rome.

WTO (1994) World Trade Organization (WTO) Sanitary and Phytosanitary Measures Agreement (SPS) (available at www.wto.org/english/tratop_e/sps_e/sps_e.htm).

2 Commodity and pathway description

2.1 Commodity description

The commodity, fresh ginger, is defined as: commercially produced ginger (*Zingiber officinale* or *Z. zerumbet*) rhizomes, with skin. The ginger rhizome is typically branched, containing yellow flesh covered by a thin brown skin. The commodity does not include roots (with the exception that *Z. zerumbet* may have dry root hairs or fine roots attached), leaves, stems, or other plant parts. The commodity definition also excludes attached soil and rhizome material which is visibly damaged or diseased (as defined in the minumum requirements in section 1.2).

2.2 Pathway description

The minimum requirements for *Zingiber officinale* or *Z. zerumbet* fresh produce do not specify growing conditions, production methods or sampling and testing methods. However, the commodity must be sourced from a production site that uses standard commercial cultivation methods including pest-control, harvesting, sorting, cleaning, inspection and packaging. Because the requirements in the IHS will be for a number of countries and all growing conditions and production methods, the IRA need to take into account pathogens which occur in some countries but not others, and pathogens which occur in some ecological and environmental conditions and not others.

While it is reasonable to consider that obviously diseased or damaged rhizomes would be precluded from export, a number of pests may not be visible or cause visible symptoms on rhizomes. For example, pathogens that can cause rotting of rhizomes may be present at asymptomatic levels, or pests e.g. some nematodes, may be present internally without presenting external symptoms.

As ginger rhizomes are subterranean, or at least largely so, there is the potential for pests and pathogens that are present in soil and either feeding externally on the rhizome or not biologically associated with it, to be present on the harvested commodity. However, the commodity description requires the rhizomes to be washed, clean and free from soil. For this reason, soil-associated organisms are not considered to be hazards on ginger rhizomes, and externally-feeding organisms are considered to be detectable if they remain associated with the rhizomes.

When a pest or pathogen arrives in a new area, it usually needs to find or come into contact with a growing host plant in order to establish. This is termed “exposure” in MPI risk assessments and “transfer” under the IPPC. In the case of fresh produce, there is no likelihood of exposure of pests and pathogens from that part of the commodity that is consumed, unless the pest is capable of actively moving off the commodity prior to consumption. There is potential for exposure from discarded waste material generated from the commodity (either parts of the commodity not generally consumed, e.g. rinds or seeds, or parts generally consumed that have degenerated to the point of being considered inedible). Waste material discarded into bagged rubbish that goes to landfill, or into kitchen disposal units that flush into the sewerage system is unlikely to be a risk. However, waste discarded into compost bins presents a potential exposure pathway. Ginger is bought in small quantities by most consumers and only a small proportion of it will generally be discarded as waste (though businesses such as supermarkets may discard larger quantities, particularly of damaged or rotting rhizomes). Therefore ginger rhizomes have a relatively low level of exposure compared to most types of fresh produce. Different types of organism will have different likelihoods of exposure from discarded ginger, based on their ability to move or be carried from compost to a host plant in the environment, and their ability to survive in the absence of a living host plant.

Discarded whole ginger rhizomes, or large pieces of rhizome containing intact nodes (which produce aerial stem and roots) could potentially grow in a compost heap. Ginger plants growing in the environment from imported ginger rhizomes would present a potential risk with respect to viruses and other insect-vectored or seed-transmitted pathogens associated with the rhizome. However, ginger is a tropical/subtropical plant, and there are no reports of naturalised ginger growing in New Zealand[16], therefore the likelihood of ginger plants growing from discarded rhizomes is considered very low. In addition, discarded whole rhizomes, or large parts of rhizomes, are likely to be in poor condition, reducing further the likelihood of sprouting. Imported ginger rhizomes could be deliberately sprouted indoors, but given that this is not the intended end use and unlikely to happen frequently, deliberate propagation is not considered further in this IRA.

2.3 Taxonomy of *Zingiber* species

Zingiber is a genus of approximately 150 species (The Plant List 2013).

Table 3 gives the names of *Zingiber* species present in New Zealand or mentioned in the IRA and their biostatus (presence/absence in New Zealand). There are no native species in the genus, and no naturalised exotic species.

Table 3. New Zealand biostatus of *Zingiber* species mentioned in the IRA

Scientific name[16]	Common name	Comments
Zingiber mioga	Myoga ginger, Japanese ginger	Sometimes cultivated, potential crop (Douglas and Follett 1992).
Zingiber officinale	ginger, Canton ginger, stem ginger	Present in New Zealand in captivity/cultivation/culture
Z. zerumbet	broadleaf ginger, Martinique ginger, wild ginger	There in an entry for this species in the Landcare New Zealand Plants database, but biostatus is not given.

2.4 The family Zingiberaceae

Zingiber belongs to the ginger family (family Zingiberaceae). The ginger family is made up of about 50 genera with a total of about 1600 known species of aromatic perennial herbs with creeping horizontal or tuberous rhizomes distributed throughout tropical Africa, Asia and the Americas. As well as culinary ginger, the family also includes the spices turmeric, galangal and cardamom. There are no New Zealand native members of the ginger family and none are grown in New Zealand as commercial crops unless on a very small scale. The exception is that a number are grown as ornamentals and therefore provide economic benefits

16 Nomenclature, including common names, as well as the wild status in New Zealand, is from Landcare Research (2019)

to the nursery industry. Some genera in the ginger family which are grown in New Zealand are listed in table 4.

Table 4. Some genera of Zingiberaceae in New Zealand

Genus	Comments
Alpinia	Ornamentals
Hedychium	Ornamentals. Two species fully naturalised and serious weeds.
Heliconia	Ornamentals
Zingiber	Occasionally cultivated.

Members of the same plant family share many pests and pathogens in common. There is a strong relationship between how closely related different plant species are and how likely they are to share pests and pathogens (for example, see Gilbert and Webb 2007[17]). This means that a genus like *Zingiber* (ginger), in the Zingiberaceae, which has relatively few related species cultivated in New Zealand, with no major crops or native species, will have relatively few pests and pathogens likely to cause major problems in New Zealand compared with a genus with many important related genera present in the country. This level of risk is likely to reduce the number of pests which potentially meet the criteria for additonal measures.

2.5 New Zealand climate

New Zealand is situated in the South Pacific and ranges from 34˚00'S and 166˚00'E to 48˚00'S and 179˚00'E. Under the Kopen-Geiger climate classification the New Zealand climate mostly falls mostly under the *Cfb* subclass which is a temperate oceanic climate. This subclass is characterised by four distinct seasons. The main contributing factors in New Zealand are the Pacific Ocean and latitude, although mountain ranges extending the length of the South Island provide a barrier for prevailing westerly winds, dividing the country into two separate climatic regions. The wettest region of the country, the West Coast of the South Island, is just over 100km away from the driest, the semi-arid Central Otago. Conditions range from cool temperate in the far south to subtropical in Northland. (Peel *et al.* 2007, NIWA 2001.)

Plants in the family Zingiberaceae are distributed in the tropics and semitropics. Climate matching with New Zealand (Phillips 2012) suggests that plants in this family, including *Zingiber* species, and by extension many of the pests and pathogens associated with these plants in their natural range, would only be able to establish in the warmer regions of New Zealand, predominantly the north of the North Island.

2.6 References for Chapter 2

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3 Hazard identification

The following section gives more information about the specific approaches taken to hazard identification for the different pest and pathogen groups in the Ginger IRA.

3.1 Method

A range of different approaches can be used for compiling the list of potential hazards to consider. The risk management question is the most important factor in determining the approach. In the case of the Ginger IRA, the risk management question is:

> Which pathogens and nematodes are associated with *Zingiber officinale* and *Z. zerumbet* fresh produce (rhizomes) meet the risk evaluation criteria for requiring additional measures (over the minimum requirements proposed in the RMP)?

Other factors to considered in determining the approach include:

- whether there is evidence that the minimum requirements can manage all members of a particular pest group, for example the group has biological traits which make them susceptible to some of the risk management measures
- whether conclusions from previous risk assessments are relevant to the current risk assessment.

Once the potential hazard list is compiled, the hazard identification answers the following questions:

- does a species[18] meet the criteria to be considered a quarantine pest for New Zealand?
- is a species associated with the commodity being assessed?

The main hazard identification approaches and the circumstances in which to use them are explained in table 5.

Table 5: Options for compiling potential hazard lists

Comprehensive	**OBJECTIVE:** identify all pests and pathogens which are potentially associated with a commodity
Selective	**OBJECTIVE:** identify all pests and pathogens which are potentially associated with the commodity and have specific traits or meet other screening criteria
Grouped	**OBJECTIVE:** identify groups of pests and pathogens where all members of that group have a similar level of risk on a particular commodity, based on certain common traits
Indicative	**OBJECTIVE:** identify examples of pests and pathogens which are associated with a commodity

18 ISPM 2 section 1.2 "The taxonomic level for organisms considered in PRA [pest risk analysis] is usually the species. The use of a higher or lower taxonomic level should be supported by a scientifically sound rationale."

The hazard identification approach to use for each group in the ginger IRA was selected during the commissioning process. The approach used and the reason for using that approach is documented in table 6.

Table 6. Specific hazard identification approaches for pest and pathogen groups asssociated with *Zingiber officinale* and *Z. zerumbet* fresh produce

Organism group	Hazard identification approach	Rationale (see sections 5-7 for further explanation)
Viruses, viroids	**Grouped** hazard identification.	Viruses were not considered in detail based on the lack of evidence for accidental propagation of ginger.
Fungi, Oomycetes, Bacteria (including phytoplasmas)	**Selective:** consider only major fungal, oomycete and bacterial pests which are reported to be latent in association with *Zingiber officinale* or *Z. zerumbet* rhizomes.	Fungi, oomycetes and bacteria were considered not to require assessment for measures beyond minimum requirements if they are either not associated with rhizomes, cause rot of ginger rhizomes that should be detected during inspection or unlikely to establish or have impacts in New Zealand.
Nematodes	**Selective** hazard identification: consider only endoparasitic nematodes reported to be associated with *Zingiber officinale* or *Z. zerumbet* roots or rhizomes and are likely to be able to establish in New Zealand and have significant impacts.	Only internally feeding nematodes are likely to be associated with ginger rhizomes that have undergone the post-harvest cleaning processes that are part of the minimum requirements.
Insects	**Selective** hazard identification: consider only insects that could be internally associated with *Zingiber officinale* or *Z. zerumbet* rhizomes and are likely to be able to establish in New Zealand and have significant impacts.	Many insects may be associated with rotting/damaged rhizomes, be present as stored product pests or hitchhikers, or be associated externally with the rhizomes (e.g. scale insects); it is considered these insects will not be associated with rhizomes which meet the commodity definition and have undergone the post-harvest cleaning processes and inspection that are part of the minimum requirements. Insects that are tropical or subtropical in origin have a lower likelihood of establishing and causing significant impacts in New Zealand.
Mites	**Selective** hazard identification.	Mites may be associated with rotting/damaged rhizomes or be

		present as stored product pests and are associated externally with the rhizomes. Although damaged rhizomes do not meet the commodity definition and mites are likely to be visible, there are a number of interceptions so some further consideration is needed.
Other invertebrates (springtails, snails, spiders, isopods)	**Grouped** hazard identification or selective for repeat interceptions	These invertebrates are largely hitchhikers. The association of hitchhikers with specific commodities is opportunistic and cannot be predicted from standard scientific literature sources. Repeated interceptions under specific circumstances is the only reliable predictor for commodity association with hitchhikers.

Hazard identification used the following sources:

- CABI Crop Protection Compendium (2018/9)
- CABI horizon scan, list of all potential risks for ginger (all *Zingiber*) imports to NZ, CABI horizon scan extract_20180319)
- CAB Abstracts
- Google scholar
- Google
- Existing pest lists from ginger IHSs
- interception data (LIMS, QuanCargo)
- Farr & Rossman (2017/2018) (for fungi and oomycetes)
- García Morales (2016) (for scale insects)
- Migeon & Dorkeld (2018) (for mites)
- Nemaplex (for nematodes)
- MPI Emerging Risks System database
- general literature searches

See Appendix 1, Section 8 for details of these sources for particular taxa.

Hazard identification, although extensive, is not exhaustive. Potential hazard lists should include most organisms which meet the screening criteria, but there may be additional organisms which were not found. The effectiveness of searching depends on the sources which are used (and accessible), the search strategies used and the time taken relative to the total numbers of associated organisms. In addition, sometimes there is insufficient existing information to know whether associated organisms meet the criteria or not.

MPI's biosecurity Emerging Risk System (ERS) collects information about new pests and pathogens, as well as new information about known pests and pathogens. The Emerging Risk System then assesses the information to determine whether it indicates a risk which may not be managed by an IHS. Therefore if information becomes available which was not available at the time this IRA was done, there is a system to identify and assess this information.

3.2 Results

The numbers of organisms considered as a part of the hazard identification are summarised in table 7. See Appendix 1, Section 8 for details.

Table 7. Results of hazard identification for ginger rhizomes.

Organism group	Summary
Viruses	2 viruses were considered in the hazard identification; more information was provided about both of them, but neither was assessed in detail.
Bacteria (including phytoplasmas)	16 bacteria were considered in the hazard identification; one was assessed in a targeted PRA, and more information was provided about 4 of them.
Fungi	61 fungi were considered in the hazard identification; more information was provided about 8 of them, but none were assessed in detail.
Oomycetes	12 oomycetes were considered in the hazard identification; more information was provided about 3 of them, but none were assessed in detail.
Insects	150 insects were considered in the hazard identification; more information was provided about 78 of them, but none were assessed in detail.
Mites	32 mites were considered in the hazard identification; more information was provided about 11 of them, but none were assessed in detail.
Nematodes	39 nematodes were considered in the hazard identification; one was assessed in a targeted PRA, and more information was provided about 24 of them.
Other invertebrates (springtails, molluscs, spiders, isopods)	28 other invertebrates were considered in the hazard identification; more information was provided about 3 of them, but none were assessed in detail.

3.3 References for Chapter 3

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Nemaplex, University of California, Davis. Available at: http://plpnemweb.ucdavis.edu/nemaplex/Uppermnus/topmnu.htm.

Migeon, A; Dorkeld F (2018) Spider Mites Web: a comprehensive database for the Tetranychidae. Availabe from http://www.montpellier.inra.fr/CBGP/spmweb

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4 Risk assessment

4.1 Method

A range of different approaches can be used for risk assessment. The most important factor in determining the approach is the risk management question and the level of assessment needed to support a robust and transparent risk management decision.

In the case of the Ginger IRA, the risk management question is specific, aiming to identify pathogens and nematodes which meet the criteria for needing additional measures over the minimum requirements.

The pest risk assessment (PRA) used is called a **targeted PRA** as it is targeted at answering a limited range of questions. The PRA method used covers the following questions:

- Does the pest or pathogen meet the criteria to be a quarantine pest?
- Is the pathogen associated with the commodity?[19]
- Does the pathogen meet the risk evaluation criteria for additional measures over the minimum requirements.

The criteria for a pest or pathogen to require measures beyond the minimum requirements for the commodity are a combination of the likelihood of the pests being removed or detected and the risk if they are not. The risk assessment first considers how likely the pest or pathogen is to be managed by the minimum requirements, based on its biological traits. Pests and pathogens which are unlikely to be removed from the rhizomes by post-harvest handling and processing or be detected by inspection at the border undergo further risk assessment.

In answering the question about whether pests or pathogens can be visually detected, it is assumed that post-harvest processing involves a degree of handling and sorting which gives all rhizomes with visible disease, damage or associated pests the opportunity to be detected and removed. However phytosanitary inspection and verification inspects only a sample and does not detect pests and pathogens below an infestation rate of 1 in 200 units.

There are three possible answers to the risk management question of whether the pest or pathogens meets the criteria. These are stated below:

- The pest or pathogen meets the criteria for additional measures.
- The pest or pathogen does not meet the criteria for additional measures.
- The pest or pathogen may meet the criteria for requiring additional measures, but this conclusion is uncertain.

The conclusion is stated as uncertain when the pest or pathogen is near the threshold for whether it not it meets the criteria. The pest or pathogen may meet some criteria but not others, or evidence may be limited. In other cases, the status of the pest or pathogen as a quarantine pest may be uncertain, or the association with ginger rhizomes may be weak. The reasons for the uncertainty are stated below the conclusion. As indicated in section 1.3.4,

19 These first two questions are part of hazard identification. They are written up in more detail for those pests and pathogens which undergo risk assessment.

pests or pathogens for which the conclusion is uncertain are considered further in the risk management proposal taking articles 2.2 and 5.7 of the SPS agreement into account..

To answer the risk management questions, the PRAs use the CASE schema[20]. Under the CASE schema, the **contention** or **conclusion** (that is, the answer to the risk management question) is presented first, followed by the **arguments** supporting this contention and the **evidence** and **sources** supporting each argument.

In addition to the PRAs, there are also summary paragraphs for some of the other pests and pathogens which were considered during hazard identification.

4.2 Results

Table 8 lists the assessed species where the evidence indicated that they required consideration in the risk management proposal.

Table 8. Species which meet criteria for further consideration in the risk management proposal.

Organism name	**Group**	Reason for uncertainty
Pratylenchus zeae	Nematode	A major pest globally on crops such as maize and nematodes are difficult to detect visually. However there is a weak association with the commodity (ginger rhizome), uncertainty about ease of detection on rhizomes, exposure of hosts in the New Zealand environment and ability to cause significant impacts in the New Zealand climate.
Pantoea ananatis	Bacterium	Can cause serious disease on some hosts such as onions and can occur latently under some circumstances. There is a weak association with the commodity (ginger rhizome). The varied nature of the bacterium and the influence of environmental conditions makes it difficult to predict how it would behave were it to enter New Zealand on ginger rhizomes.

20 The CASE schema is a method for presenting the reasoning which supports or contradicts a particular contention or conclusions. Presenting the evidence in this way makes it easier for readers to understand the basis for the conclusion and to see if the evidence is weak or important sources have been missed. Further information can be found at the following link: https://timvangelder.com/2019/04/07/what-is-the-case-schema/

5 Nematodes

Pratylenchus zeae was considered the only nematode to require further assessment (a targeted PRA) to determine if it meets the criteria for requiring measures beyond minimum requirements. All other nematodes identified did not require further assessment.

5.1 *Pratylenchus zeae* – targeted PRA

This targeted Pest Risk Assessment (PRA) assesses the risk to New Zealand of *Pratylenchus zeae* on imported ginger (*Zingiber officinale* and *Z. zerumbet*) fresh produce (rhizomes).

Description
Pratylenchus zeae is a widely distributed, parthenogenetic nematode, 0.4 - 0.5mm long. It is a migratory endoparasite of plant roots, i.e. it enters the root system and feeds from cells as it moves within a root. It has a wide host range but is predominantly a pest of a number of tropical and subtropical graminaceous crops.

Scientific name: *Pratylenchus zeae* Graham, 1951
Order: Rhabditida (modern phylogeny)/Tylenchida (classical phylogeny)*
Family: Pratylenchidae
Other names: *Pratylenchus indicus* Das, 1960
Common name: corn root lesion nematode
* The modern phylogeny (De Ley & Baxter 2002, 2004 – cited in De Ley 2006) is based primarily on molecular characters, the classical phylogeny is based on morphological characters.

5.1.1 Conclusion summary

Pratylenchus zeae meets the criteria to be a quarantine pest for New Zealand

- *Pratylenchus zeae* is not known to be present in New Zealand.
- There is the potential for *P. zeae* to establish in New Zealand due to favourable climatic conditions, host availability and opportunity for exposure from imported ginger rhizomes.
- There is potential for *P. zeae* to have impacts on plants of importance to New Zealand.

Pratylenchus zeae has a weak association with rhizomes of ginger in countries within the scope of this assessment, i.e. those eligible to export ginger fresh produce to New Zealand under the proposed new Import Health Standard

- *Pratylenchus* zeae is associated with ginger roots and may be associated with ginger rhizomes.
- *Pratylenchus zeae* occurs in countries within the scope of this assessment, i.e. those eligible to export ginger (*Zingiber officinale* or *Z. zerumbet*) to New Zealand under the proposed new Import Health Standard:

Pratylenchus zeae may meet the criteria for requiring additional measures, but this conclusion is uncertain, given that:

- Post-harvest processing such as soil removal is unlikely to remove or kill *Pratylenchus zeae* in association with ginger roots and rhizomes.
- Visual inspection is unlikely to detect infestation of low numbers of *P. zeae* associated with imported ginger rhizome
- Small amounts of waste ginger discarded onto compost heaps is the only likely exposure pathway
- *P. zeae* is likely to be able to establish in New Zealand, at least in the warmer parts of the country. Host plants are common and widespread in New Zealand and the nematode is present in several other countries with a similar climate to New Zealand
- In addition, as stated in section 5.1.3 , commodity association is weak. Ginger appears not to be a common host for *P. zeae*; this nematode may only infrequently be associated with ginger roots/rhizomes, and if so, it is likely to be in low numbers. It is uncertain whether *P. zeae* attacking ginger would move from the true roots into the rhizome, and if so, in what numbers.
- As stated in section 5.1.2, it is uncertain whether *P. zeae* would thrive in the climatic conditions in New Zealand to the point of becoming a significant pest. This nematode has a very wide host range and is a significant pest of crops overseas, including crops of importance to New Zealand. However, it is a pest primarily in the tropics and subtropics, and climatic conditions in this country would not be optimal; it is not known what population levels would be achieved in New Zealand conditions.

5.1.2 Hazard identification: quarantine pest status

Pratylenchus zeae meets the criteria to be a quarantine pest for New Zealand

***Pratylenchus zeae* is not known to be present in New Zealand:**

- It is not recorded in Gordon (2010), NZOR (accessed 9 Jul 2018) or PPIN (accessed 9 Jul 2018).
- It is regulated in BORIC (MPI's Biosecurity Organisms Register for Imported Commodities).

There is the potential for *P. zeae* to establish in New Zealand due to favourable climatic conditions, host availability and opportunity for exposure from imported ginger rhizomes:

- *Pratylenchus zeae* is widespread in tropical and subtropical regions, but is also present in several more temperate areas:
    - It is known from parts of Asia (Afghanistan, China – Fujian and Hainan provinces, India, Indonesia, Iraq, Japan, Malaysia, Oman, Pakistan, Philippines, Sri Lanka, Taiwan, Turkey, Vietnam), is widespread in Africa and Central America/the Caribbean, is present in Canada and some southern states of USA (and Hawaii), several South American countries (Argentina, Brazil, Colombia, Ecuador, Venezuela), several European countries (Austria, Bulgaria, Croatia, Slovenia) and parts of Oceania (NSW, Queensland and

Western Australia in Australia, Fiji, Papua New Guinea, Samoa,(CPC 2018), Thailand (Plant Pests in Thailand 2016) and Tonga (Orton Williams 1980)).
    - The Atlas of Living Australia (accessed 16 May 2019) also records a specimen of *P. zeae* from Northern Territory in Australia. Yu (2008), reporting species of *Pratylenchus* from Canada, records *P. zeae* only from Ontario, the southernmost province of the country.
  - CPC (2018) does not list Thailand as part of the distribution of *P. zeae*. However, other publications indicate this nematode is present in Thailand. The Plant Pests in Thailand (2016) website states "Chunram (1972) [this publication could not be accessed] found outbreaks of *Pratylenchus zeae* in many plants throughout Thailand." Other references cited on this website (none of which could be accessed) also refer to the presence of *P. zeae* in Thailand. Arayarungsarit (1991) carried out PhD research on *P. zeae* in upland rice in Thailand. Toida *et al.* (1996) collected and identified plant-parasitic nematodes, including *P. zeae*, attacking crops in Thailand.
- While the known distribution of *P. zeae* is largely tropical and subtropical, it is also present in some countries that have a good climate match with New Zealand (Climate Match Index tool – Phillips 2012): China, Turkey, South Africa, Canada, USA (present in some south-eastern states), Argentina, Austria, Bulgaria, Croatia, Slovenia and Australia (present in NSW, Queensland, Northern Territory and Western Australia). However, for some of these countries/regions, distribution may be restricted to warmer areas. For example, CPC (2018) records *P. zeae* from China, but only from Fujian and Hainan provinces in the south; neither of which has good climate match with New Zealand. CPC (2018) records the nematode from NSW in Australia, but it is unknown how far south in this state it is distributed; the Atlas of Living Australia records 20 specimen records, of which 18 are from Queensland, one from Northern Territory and one has no location assigned. Nevertheless, it is likely that the climate in parts of New Zealand at least would be suitable for the establishment of *P. zeae*.
- An assessment by Walter & Karssen (2015) that used CLIMEX modelling to estimate the likelihood of *P. zeae* establishing in the Netherlands and Belgium concluded that the pest could become established in Belgium but not the Netherlands, as a result of the cooler climate in the Netherlands. The model was also used to predict worldwide which countries that do not have *P. zeae* would have a suitable climate for its establishment; New Zealand was identified as one of the countries of "potential danger".
- *Pratylenchus zeae* has a wide host range and few specific habitat requirements (CPC 2018). It is predominantly a pest of a number of tropical and subtropical graminaceous crops, in particular maize, rice, sorghum and sugarcane, but known hosts include many economically important plants that are present in New Zealand. In addition, many weed species are likely to be adequate hosts for the nematode to survive and reproduce on.
  - Known hosts of importance to New Zealand include *Allium cepa (onion), Allium sativum (garlic)*, ***Capsicum annuum (pepper)***, ***Acca sellowiana* (feijoa)**, *Festuca arundinacea* (tall fescue), ***Fragaria x ananassa***

(strawberry), *Lactuca sativa* (lettuce), *Medicago sativa* (lucerne), *Paspalum notatum* (paspalum), Poaceae (grasses), ***Prunus persica* (peach/nectarine)**, **Solanaceae (nightshades)**, ***Solanum lycopersicum* (tomato)**, ***Solanum melongena* (eggplant)**, ***Solanum tuberosum* (potato)**, ***Secale cereale* (rye)**, ***Sorghum bicolor* (sorghum)** and ***Zea mays* (maize)** (CPC 2018, Nemaplex – accessed 9 Jul 2018). Hosts in **bold** are listed by CPC as 'Main' hosts or by Nemaplex as 'Susceptible'.
    - Bellé *et al.* (2017) evaluated 25 weed species as hosts of *P. zeae* by inoculating plants in a glasshouse with the nematode. Families of weed species tested were Amaranthaceae, Asteraceae, Brassicaceae, Convolvulaceae, Euphorbiaceae, Malvaceae and Poaceae. All tested weeds were susceptible to *P. zeae* (the nematode was able to reproduce on the plants and increase population size). The tested plants included *Lolium multiflorum* (Italian ryegrass), an important component of New Zealand pastures (Toy 2013). While *L. multiflorum* was one of a group of the test plants that exhibited the smallest increase in *P. zeae* population, it was still susceptible to, and a host for this nematode.
        - The Bellé *et al.* (2017) trial suggests that many plants will be capable of acting as hosts of *P. zeae* to a degree that allows the nematode to maintain or increase populations in the field in the absence of favoured hosts.

There is potential for *P. zeae* to have impacts on plants of importance to New Zealand:

- *Pratylenchus zeae* is a migratory endoparasite of the cortex of plant roots, entering smaller roots at any point and feeding from cells as it moves within the root. It causes mechanical damage to root cells, necrosis of root tissues and lesions in the root cortex. Above-ground symptoms are non-specific, such as stunting, wilting and yellowing of leaves. It has a wide host range but is predominantly a pest of a number of tropical and subtropical graminaceous crops, principally rice, maize, sorghum and sugarcane. (CPC 2018, Nemaplex – accessed 11 Mar 2019, Walter & Karssen 2015.)
- *Pratylenchus zeae* is recognized as one of the major nematodes responsible for crop losses worldwide, with the greatest economic losses reported for sugarcane and maize crops. Croplands infested with this pathogen can become infeasible for the cultivation of new crops of these species as well as other crops equally susceptible to this nematode, making the economic use of the lands unsustainable (Bellé *et al.* 2017).
- Maize is assessed to be the 6th most valuable economic plant in New Zealand (NZIER 2016), and sorghum has become increasingly popular with New Zealand farmers during the last decade (Specialty Seeds 2019). In addition, a number of other plants that are economically important in this country are known hosts of *P. zeae* (see above).
- Bellé *et al.* (2017) found in inoculation trials that *P. zeae* could survive and reproduce on *Lolium multiflorum* (Italian ryegrass), an important component of New Zealand pastures (Toy 2013). Bellé *et al.* (2017) noted that while population growth was low on *L. multiflorum*, this plant was still susceptible to, and a host for *P. zeae*, which "increases the concern about the presence of this species in farming areas."

- *Pratylenchus zeae* is distributed largely in tropical and subtropical regions. While it is likely to be able to establish in New Zealand, at least in warmer regions, it is uncertain whether *P. zeae* would thrive in the climatic conditions in this country to the point of becoming a significant pest. Assessing the risk of this nematode to Belgium, Walter & Karssen (2015) concluded that while it is likely to be able to establish, Belgium would be on the edge of its distribution and therefore the impact would probably be very low. Looking at potential world distribution, they considered New Zealand to be a country of "potential danger".

5.1.3 Hazard Identification: Commodity association

Pratylenchus zeae has a weak association with rhizomes of ginger in countries within the scope of this assessment, i.e. those eligible to export ginger fresh produce to New Zealand under the proposed new Import Health Standard

***Pratylenchus* zeae is associated with ginger roots and may be associated with ginger rhizomes.**

- *Pratylenchus zeae* is reported to be associated with ginger
  - Kaur *et al.* (1989) reported *P. zeae* from ginger in Himachal Pradesh, India, and stated this was a new host record for this nematode;
  - The Plant Pests of Thailand (2016) website lists *Zingiber officinale* as a "main host plant" of *P. zeae*, but also lists *Z. officinale* under "other hosts". The listing in one of these categories is clearly erroneous. No information is given about the status of *P. zeae* as a pest on ginger. Toida *et al.* (1996) collected and identified plant-parasitic nematodes, including *P. zeae*, attacking crops in Thailand, but do not mention ginger (though a full host list for each nematode is not provided);
  - CPC (2018) lists *Zingiber officinale* as an 'Other' host, though the source is not recorded;
- Records indicate that ginger is not a common host for *P. zeae*
  - Nemaplex (accessed 7 March 2019) does not record ginger as a host for *P. zeae*;
  - Koshy & Bridge (1990) state that the most important nematode parasites of ginger are *Meloidogyne* spp., *Radopholus similis* and *Pratylenchus coffeae*[21]. They list 10 other species of nematode that have been recorded from ginger; *P. zeae* is not included;
  - Orton Williams (1980) lists 43 crop hosts plant species for *P. zeae* in the South Pacific; ginger is not included;
  - Bridge (1988), assessing plant-parasitic nematode problems in the Pacific Islands notes, in the Abstract, that staple food crops have serious nematode pests, such as *Meloidogyne* spp. on sweet potato, *Hirschmanniella miticausa* on taro, *Pratylenchus coffeae* and *Radopholus* sp. on yams, *P. coffeae* and *Radopholus similis* on banana, *Tylenchulus semipenetrans* on citrus, *Aphelenchoides besseyi* on rice and *Meloidogyne* spp. and *R. similis* on ginger.

21 Pratylenchus coffeae is not a quarantine pest. See section 5.2 and Appendix 1 for discussion of other nematodes associated with ginger.

This is followed by the statement: "*Rotylenchulus reniformis, P. zeae, P. brachyurus* and *Helicotylenchus* spp. are important on all of these and other crops." However, in the text and table entry relating to ginger (*Zingiber officinale*), *Meloidogyne* spp. and *Radopholus similis* are given as the most important nematode pests, with only *Rotylenchulus reniformis, Criconemella onoensis* and *Pratylenchus coffeae* mentioned as other nematodes implicated in disease of ginger;
    - No other records of ginger as a host for *P. zeae* were found, and no references to this nematode as a pest of ginger were found;
    - For both New Zealand and EPPO countries, there are no records of *P. zeae* being intercepted at the border and no record of any *Pratylenchus* species being intercepted on ginger (LIMS 1998-2018, EPPO interceptions on imported commodities 1999-2018).

- *Pratylenchus zeae* is associated with roots and would therefore be associated with *Z. zerumbet*
    - *Pratylenchus zeae* is a migratory endoparasite of the root cortex, entering smaller roots at any point. All stages are found in the outer parenchyma cells and never in the vascular tissues (CPC 2018).
- It is uncertain whether *P. zeae* is associated with ginger rhizomes but this is likely based on other species of *Pratylenchus*
    - *Pratylenchus zeae* has not been reported in ginger rhizomes
        - It is uncertain how far *P. zeae* can travel within the root system and whether in ginger they move from the true roots into the rhizome, and if so in what numbers relative to numbers in the roots.
    - Other *Pratylenchus* species (they are all migratory endoparasites) have been found in ginger rhizomes.
        - *Pratylenchus coffeae* is associated with rhizome rot of *Z. officinale* in India, where 10g of rhizome peel yielded over 3,100 adults and juveniles in one study; in another study in India a species reported as *P.* cf *pratensis* was recorded from *Z. officinale* rhizome (Thapa *et al.* 2008).

***Pratylenchus zeae* occurs in countries within the scope of this assessment, i.e. those eligible to export ginger (*Zingiber officinale* or *Z. zerumbet*) to New Zealand under the proposed new Import Health Standard:**

- Countries within the scope of this assessment, i.e. those eligible to export ginger (*Zingiber officinale* or *Z. zerumbet*) to New Zealand under the proposed new Import Health Standard, and from which *P. zeae* has been reported, are Australia, China, Fiji, Papua New Guinea, Samoa, Thailand and Tonga.
- *Pratylenchus zeae* has been reported from Australia, China, Fiji, Papua New Guinea, Samoa, Thailand and Tonga (see 'Hazard identification: quarantine pest status' section above).
- However, no records were found of *P. zeae* associated with ginger in these countries, other than Thailand (and possibly the Pacific Islands – the information in the report

concerning this is contradictory) (see 'Hazard Identification: Commodity association' section above).

Pratylenchus zeae is also present in soil, and could therefore be present in any soil attached to ginger imported from countries where *P. zeae* is present. However, minimum requirements require ginger to be free of soil.

5.1.4 Assessment against criteria for requiring additional measures

Pratylenchus zeae may meet the criteria for requiring additional measures, but this conclusion is uncertain, given that:

- Post-harvest processing such as soil removeal is unlikely to remove or kill *Pratylenchus zeae* in association with ginger roots and rhizomes.
- Visual inspection is unlikely to detect infestation of low numbers of *P. zeae* associated with imported ginger rhizome
- Small amounts of waste ginger discarded onto compost heaps is the only likely exposure pathway
- *P. zeae* is likely to be able to establish in New Zealand, at least in the warmer parts of the country. Host plants are common and widespread in New Zealand and the nematode is present in several other countries with a similar climate to New Zealand
- In addition, as stated in section 5.1.3, commodity association is weak. Ginger appears not to be a common host for *P. zeae*; this nematode may only infrequently be associated with ginger roots/rhizomes, and if so, it is likely to be in low numbers. It is uncertain whether *P. zeae* attacking ginger would move from the true roots into the rhizome, and if so, in what numbers.
- As stated in section 5.1.2, it is uncertain whether *P. zeae* would thrive in the climatic conditions in New Zealand to the point of becoming a significant pest. This nematode has a very wide host range and is a significant pest of crops overseas, including crops of importance to New Zealand. However, it is a pest primarily in the tropic and subtropics, and climatic conditions in this country would not be optimal; it is not known what population levels would be achieved in New Zealand conditions.

The criteria for a pest or pathogen to require measures beyond the minimum requirements for the commodity are a combination of the likelihood of the pests being removed or detected and the risk if they are not. The risk assessment first considers how likely the pest or pathogen is to be managed by the minimum requirements, based on its biological traits. Pests and pathogens which are unlikely to be removed from the rhizomes by post-harvest handling and processing or be detected by inspection at the border undergo further risk assessment.

The proposed minimum risk management requirements for the import of fresh ginger include commercial cultivation methods, visual inspections for pests and ensuring that the rhizomes are free from soil and other contaminants, damage and defects. Therefore the minimum requirements may not manage pests which occur internally in the rhizomes (and roots for *Z. zerumbet*) or which cannot be seen by visual inspection.

Post-harvest processing such as soil removal is unlikely to remove or kill *Pratylenchus zeae* in association with ginger roots and rhizomes.

- *Pratylenchus zeae* is a migratory endoparasite of the cortex of plant roots, entering smaller roots at any point and feeding from cells as it moves within the root. All stages are found in the outer parenchyma cells (CPC 2018).

Visual inspection is unlikely to detect infestation of low numbers of *P. zeae* associated with imported ginger rhizome.

- In relation to the detection of *P. zeae* on infested host bulbs, tubers, corms or rhizomes, CPC (2018) states that the pest or symptoms are not visible to the naked eye but usually visible under a light microscope.\Walker & Carson (2015) note that necrotic lesions can be observed on the root surface of hosts infested by *P. zeae*, but this may apply more to favoured hosts where large infestations are more likely than in ginger, and symptoms in true roots may not relate to symptoms in rhizomes.
- *Pratylenchus coffeae* has been associated with rhizome rot of *Z. officinale* in India (Thapa *et al.* 2008), but *P. coffeae* is known as one of the most significant nematode pests of ginger (Nair 2013, Koshy & Bridge 1990) and can infest the rhizomes in large numbers (Thapa *et al.* 2008); this is unlikely to be the case for *P. zeae*.
- Nair (2013) states that nematodes enter ginger rhizomes and penetrate the tissue intracellularly, with large infestations resulting in the destruction of tissues and the formation of channels and galleries within the rhizomes, and that secondary organisms eventually rot the entire rhizome. But again, given that ginger appears not to be a favoured host for *P. zeae*, large infestations are unlikely.
- There are over 50 records of *Pratylenchus coffeae* or *Pratylenchus* sp. being intercepted at the New Zealand border (LIMS 1998-2018), mostly from Fiji and mostly on taro. The level of infestation is not recorded, but it does indicate that it is possible to visually detect some *Pratylenchus* infestations.

Exposure of hosts in the environment to *P. zeae* entering the country in ginger rhizomes is likely to be a limiting factor for establishment. However many host plants for *P. zeae* are widespread in New Zealand and the climate in parts of the country at least is likely to be suitable for *P. zeae* to establish

Factors mitigating against exposure and establishment are:

- Small amounts of waste ginger discarded onto compost heaps is the only likely exposure pathway
    - Ginger is a commodity bought in small volumes by most consumers, and only a small proportion of it will generally be discarded as waste (though businesses such as supermarkets may discard larger quantities, particularly of damaged or rotting rhizomes).
    - Not all discarded ginger waste presents a risk. Waste discarded into bagged rubbish that goes to landfill, or into kitchen disposal units that flush into the sewerage system, is unlikely to be a risk. However, ginger discarded into compost bins presents a potential exposure pathway.

- If *P. zeae* is present in the ginger, it is unlikely to be in high densities, given that ginger does not appear to be a favoured host.
- *P. zeae* is unlikely to be able to move actively from discarded ginger to a new host.

Factors favouring exposure and establishment are:

- The reproductive strategy (parthenogenesis) of *P. zeae* and the short life cycle is likely to aid establishment, particularly from small founding populations (Walter & Karssen 2015).
- While *P. zeae* cannot actively move far, it can be carried in ground water or moved considerable distances in soil/compost transported, either deliberately or not, by humans.
- *Pratylenchus zeae* has the ability to survive adverse conditions and for periods of time in the absence of hosts.
    - Root-lesion nematodes (*Pratylenchus* spp.) obtain sustenance only from living root material, but may survive from crop to crop in dead root debris and in soil (Smiley 2015).
    - *Pratylenchus* eggs can survive adverse conditions in the absence of host plants. They are covered by three layers; this shell allows them to resist drying for long periods and facilitates dispersion into new environments (Castillo & Vovlas 2007).
    - Many *Pratylenchus* species are well adapted to abiotic stress and are capable of cryptobiosis i.e. the ability to enter a state of suspended metabolic activity during unfavourable environmental conditions (drying, heat, cold). Some species can undergo anhydrobiosis in all life stages. Anhydrobiotic organisms can lose 95-98% of their body water and survive in a desiccated state for long periods, during which they have an increased resistance to environmental extremes (especially freezing temperatures) and ionising radiation, and are unaffected by metabolic poisons, including nematicides (Castillo & Vovlas 2007, Barrett 1991). However, no specific reference to *P. zeae* as an anhydrobiotic species was found, and Walter & Karssen (2015) note that this nematode cannot thrive under extremely low temperatures and therefore cannot become established in countries with extreme cold climatic conditions.

Conclusion

- Post-harvest processing such as soil removeal is unlikely to remove or kill *Pratylenchus zeae* in association with ginger roots and rhizomes.
- Visual inspection is unlikely to detect infestation of low numbers of *P. zeae* associated with imported ginger rhizome
- Small amounts of waste ginger discarded onto compost heaps is the only likely exposure pathway
- *P. zeae* is likely to be able to establish in New Zealand, at least in the warmer parts of the country. Host plants are common and widespread in New Zealand and the nematode is present in several other countries with a similar climate to New Zealand
- As stated in section 5.1.3, commodity association is weak. Ginger appears not to be a common host for *P. zeae*; this nematode may only infrequently be associated with

ginger roots/rhizomes, and if so, it is likely to be in low numbers. It is uncertain whether *P. zeae* attacking ginger would move from the true roots into the rhizome, and if so, in what numbers.

- As stated in section 5.1.2, it is uncertain whether *P. zeae* would thrive in the climatic conditions in New Zealand to the point of becoming a significant pest. This nematode has a very wide host range and is a significant pest of crops overseas, including crops of importance to New Zealand. However, it is a pest primarily in the tropics and subtropics, and climatic conditions in this country would not be optimal; it is not known what population levels would be achieved in New Zealand conditions.

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5.2 Other nematodes

Appendix 1 (Section 8) lists the potential nematode hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following nematodes were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Family	Organism	Reason for no further assessment

Criconematidae	*Mesocriconema onoense, Discocriconemella discolabia, Criconemella onoensis, Hemicriconemoides cocophillus, Macroposthonia denoudeni, Caloosia longicaudata*	Plant-parasitic nematodes in this family are ectoparasitic i.e. they are free-living in the soil and feed externally on plant roots. Free-living nematodes do not meet criteria for further assessment as minimum requirements specify removal of soil.
Dolichodoridae	*Quinisulcius* sp.	Plant-parasitic nematodes in this family are ectoparasitic i.e. they are free-living in the soil and feed externally on plant roots. Free-living nematodes do not meet criteria for further assessment as minimum requirements specify removal of soil.
Longidoridae	*Xiphinema insigne, X. krugi*	Plant-parasitic nematodes in this family are ectoparasitic i.e. they are free-living in the soil and feed externally on plant roots. Free-living nematodes do not meet criteria for further assessment as minimum requirements specify removal of soil.
Hoplolaimidae	*Helicotylenchus abunaamai, H. egyptiensis, H. indicus, H. mucronatus, H. multicinctus, Helicotylenchus* sp., *Hoplolaimus indicus, H. seinhorsti*	Plant-parasitic nematodes in this family are usually ectoparasitic i.e. they are free-living in the soil and feed externally on plant roots. Free-living nematodes do not meet criteria for further assessment as minimum requirements specify removal of soil. *Helicotylenchus* species can sometimes feed inside the root cortex, but migration through the root tissues has not been reported; association is with roots rather than rhizome – *Helicotylenchus* species are not typically carried on rhizomes, bulbs, tubers or corms in trade or transport; cleaning/drying of ginger rhizomes will remove most feeder roots and drying of any remaining fine roots in storage will further reduce the numbers of nematodes (DAWR 2013).
Hoplolaimidae	*Rotylenchulus reniformis, Rotylenchulus* sp.	*Rotylenchulus reniformis* is a sedentary, semi-endoparasite of roots in the mature female stage i.e. only the anterior part of the body is embedded in the root tissue, the posterior part of the body remains outside the root; reproduction is sexual, but there is some evidence of parthenogenesis; eggs are laid in a gelatinous matrix outside of the root, but may be associated with the root surface; males are not plant-parasites; very wide host range, including economically important plants; widely distributed in many tropical and subtropical regions of the world (Ferris 2019a). Very wide host range. Largely confined to tropics and subtropics but also found in warm temperate localities (CPC 2018a).

		Association with ginger rhizome, as opposed to true roots, uncertain, though CPC (2018a) lists bulbs/tubers/corms/rhizomes as plant parts liable to carry the pest in trade/transport. Eggs may be present on ginger rhizome surface, but are unlikely to remain after (or survive) cleaning and drying. Adult females may be present in the rhizome, but as most of the body is external to the rhizome, are unlikely to survive cleaning/drying. Nematodes which are not internal in the rhizome do not meet criteria for further assessment as minimum requirements specify removal of soil, a process which nematodes with most of their body outside the rhizome are unlikely to survive. Males are not parasitic and unlikely to be associated with imported rhizomes, and reproduction is generally sexual; uncertain how this would affect likelihood of establishment as there is some evidence of parthenogenesis and females may already be mated. May not have significant impacts if it established in NZ due to climate.
Aphelenchoididae	*Aphelenchoides* sp.	Some *Aphelenchoides* species are endoparasites in leaves, or can feed ectoparasitically on leaf and flower buds in some plants, but many species feed on fungi in the soil (Ferris 2019b). Foliar nematodes in the genus access above-ground parts of plants by using water films to migrate externally up stems before invading plant tissues (Lambert & Bikal 2009) i.e. do not move through the roots/stem internally to leaves. So, *Aphelenchoides* species would not be associated with ginger rhizomes, though could be in soil around the rhizomes; Nematodes in soil around the rhizome do not meet criteria for further assessment as minimum requirements specify removal of soil.
Anguinidae	*Ditylenchus* sp.	Most *Ditylenchus* species are mycophagous; only a few are parasites of higher plants, of which only three species (*D. dipsaci*, *D. destructor* and *D. angustus*) are of great economic importance. Most of the phytoparasitic species live as endoparasites in above-ground parts of plants, or in root, stolons, tubers or rhizomes, while *D. angustus* feeds ectoparasitically (Sturhan & Brzeski 1991). *Ditylenchus dipsaci* and *D. destructor* are both present in NZ and considered indigenous (NZOR – accessed 5 Apr 2019); *D. angustus* is ectoparasitic and therefore doesn't meet criteria for further assessment. Ginger is not listed as a host of any *Ditylenchus* species in the Nemaplex host database (Nemaplex – accessed 5 Apr 2019). No *Ditylenchus* species is listed as a pest of *Zingiber officinale* (CPC 2018b) or *Z. zerumbet* (CPC 2018c) in CABI's Crop Protection Compendia. Orton Williams (1980), surveying plant-parasitic nematodes of the Pacific, recorded "*Ditylenchus* spp." from *Z. officinale* on Viti Levu (Fiji), but

		no Ditylenchus species on ginger from any other location in the South Pacific. Unlikely to be associated with the commodity. Some plant parasitic *Ditylenchus* species may potentially be associated internally with ginger root; however ginger does not appear to be a typical host for this genus of nematodes, and there is no evidence that significant pest species in the genus attack ginger.
Heteroderidae	*Meloidogyne enterolobii* (Pacara earpod tree root-knot nematode)	The first record of ginger (*Z. officinale*) as a host of *M. enterolobii* was in China (in a commercial field of ginger) in 2018 (MPI 2018). *Meloidogyne enterolobii* is polyphagous and has many host plants including cultivated crops and weeds; typical above-ground symptoms include stunted growth, wilting and leaf yellowing; overall, damage due to *M. enterolobii* may consist of reduced quantity and quality of yield; mostly tropical and subtropical, but Mediterranean climates considered suitable and can establish in glasshouses (EPPO 2014). Distribution: China, Vietnam, Thailand, India (restricted distribution), Sub-Saharan Africa, South Africa, USA (restricted distribution), Mexico, Central America/Caribbean, Brazil, Venezuela, Switzerland (few occurrences in glasshouses) (EPPO 2019). CPC (2019) says 'infested soil and growing media, plants for planting, bulbs and tubers from countries where *M. enterolobii* occurs are the most probable pathways'. However, the EPPO (2010) considers the most relevant pathways to be host plants with roots and plant products that may have soil attached, such as tubers, bulbs and rhizomes, and specifically states 'the nematode can only be found in roots, not in tubers, bulbs or rhizomes' and gives cleaning of such plant parts as a possible measure. *Zingiber zerumbet* rhizomes may be imported with roots attached, but *M. enterolobii* is not present in countries from which *Z. zerumbet* can be imported. Doesn’t meet criteria for further assessment.
Heteroderidae	*Meloidogyne thailandica*	A new *Meloidogyne* sp. (*M. thailandica*) was described from roots of ginger intercepted from Thailand at San Francisco, USA, associated with significant symptoms; morphological similarity to other *Meloidogyne* on ginger means it could have been overlooked in the past (Handoo *et al.* 2005). No evidence found that *M. thailandica* has hosts other than ginger or is present outside of Thailand; its likely tropical distribution and specificity to a host that is not significant to New Zealand means it would be unlikely to find a host when it arrived in New Zealand or have significant impacts if it established in New Zealand.
Heteroderidae	*Meloidogyne* sp.	There are several reports of *Meloidogyne* sp. associated with ginger. *Meloidogyne incognita*, *M. arenaria* and *M. javanica* (all present in New Zealand) have been reported from ginger from a number of countries (Handoo *et al.* 2005, DAWR

		2013); it is likely that *Meloidogyne* sp. reported from ginger is one of these species.
Pratylenchidae	*Radopholus similis* (burrowing nematode)	Wide host range; a tropical nematode that can become a pest of any of the susceptible host crops in subtropical and tropical climates; crops in temperate climates are not at risk (CPC 2018d). *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; incipient infections of rhizomes result in small shallow water-soaked lesions; 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 (DAWR 2013). Does not meet criteria for further assessment as rhizomes with lesions or other evidence of defects or damage are not included in the commodity description. May be able to establish in the warmer parts of New Zealand, but sub-optimal climatic conditions mean it would be unlikely to have a significant impact.
Pratylenchidae	*Pratylenchus brachyurus* (root-lesion nematode)	Very wide host range. Widely distributed throughout tropical and subtropical regions of the world - temperature and soil type influence its distribution. (CPC 2018e). CPC (2018e) lists gingers as an 'Other' host for *P. brachyurus*, but there is little other evidence that *P. brachyurus* is typically associated with ginger: a survey of plant-parasitic nematodes in the South Pacific does not list ginger as a host for this species (though it is present in the region) (Orton Williams 1980); ginger is not listed as a host in the Nemaplex host range database (Nemaplex – accessed 8 Apr 2019); it is not listed as a pest of ginger in publications about plant-parasitic nematode problems in the Pacific Islands (Bridge 1988), in subtropical and tropical agriculture generally (Koshy & Bridge 1990) or in the production of turmeric and ginger (Nair 2013), although the latter publication does cite a 1929 reference to it being associated with turmeric. Unlikely to be associated with imported ginger rhizome. May not be able to establish in New Zealand, e.g. it is widespread in Queensland in Australia, but not present in NSW (CPC 2018e). Even if it was able to establish in the warmer parts of New Zealand sub-optimal climatic conditions mean it would be unlikely to have a significant impact.

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6 Bacteria

Pantoea ananatis was considered the only bacterium to require further assessment (a targeted PRA) to determine if it meets the criteria for requiring measures beyond minimum requirements. All other bacteria identified did not require further assessment.

6.1 *Pantoea ananatis* – targeted PRA

Description
Pantoea ananatis is also an emerging bacterial pathogen of plants and has been associated with sporadic outbreaks of disease causing significant economic impacts.

Scientific name: *Pantoea ananatis* (Serrano, 1928) Mergaert et al, 1993
Order/Family: Enterobacteriales/Enterobacteriaceae
Other names: Synonyms- *Erwinia ananatis* Serrano, 1928; *Erwinia uredovora* (Pon et al 1954) Dye 1963, *Bacillus ananas* (Serrano 1928) Patel and Kulkarni 1951, *Erwinia herbicola* var. *ananas'* (Serrano 1928) Dye 1969. Common names- fruitlet rot of pineapple.

Taxonomy and pathogenicity
Pantoea ananatis is a gram negative, facultative anaerobic bacterium. It is ubiquitous in the environment and is often associated with plants as an epiphyte, endophyte or symbiont as well as sometimes being pathogenic (Coutinho et al, 2009). The bacterium has been found as a saprophyte in numerous environments (Weller-Stuart et al, 2017).

The variation in the type of assocation it has with plants has led to a prediction that there must be different strains of *P. ananatis*, but none have been formally described (Kido et al, 2010). The varied nature of the bacterium makes it difficult to predict how *P. ananatis* may behave on different hosts, under different environmental conditions or in a different geographic range.

An example of the complex nature of *P. ananatis* is its association with *Oryza sativa* (rice). On this host the bacterium has been isolated from healthy plants as an epiphyte (Watanabe et al, 1996), endophyte (Mano and Morisaki, 2008), as well as causing 'palea' browning and stalk rot (Cother et al, 2004; Cortesi and Pizzatti, 2007). It has also been isolated from resistant and susceptible clones of *Eucalyptus grandis* x *E. nitens* (Coutinho et al, 2009). On susceptible clones the pathogen causes leaf blight and dieback (Coutinho et al, 2002).

Disease outbreaks caused by *P. ananatis* occur sporadically, but have been associated with severe economic losses. The sporadic occurence of these disease outbreaks may be due to the opportunistic nature of *P. ananatis* as a pathogen (Coutinho et al, 2009).

This PRA assesses *P. ananatis* as a species, which is the recommended approach in ISPM (2/11) unless there is a good reason to do otherwise. The extreme phenotypic variation in how *P. ananatis* interacts with host plants and the environment suggests that it may be more appropriate to regulate entities below the species level. However there is currently insufficient evidence to determine what those entities are.

Therefore, there is significant uncertainty in the assessment of *P. ananatis* due to the extreme variation within the species.

6.1.1 Conclusion summary

Pantoea ananatis meets the criteria to be a quarantine pest for New Zealand.

- *Pantoea ananatis* is not known to be present in New Zealand:
- There is the potential for *P. ananatis* to establish in New Zealand due to the favourable climatic conditions, host and potential vector availability:
- There is potential for *P. ananatis* to have impacts on plants of importance to New Zealand:

Pantoea ananatis is associated with rhizomes of *Zingiber officinale* (ginger) in countries within the scope of this IRA:

- *Pantoea ananatis* is associated with ginger rhizomes.
- *Pantoea ananatis* occurs in countries within the scope of this IHS, although records have not been found of it associated with symptoms in these countries.

Pantoea ananatis meets the criteria to be considered for additional measures, but there is significant uncertainty in the conclusion.

- *Pantoea ananatis* may not be detected by minimum management measures:
- *Pantoea ananatis* is a significant pathogen in different parts of the world*:*
- There is significant uncertainty regarding the circumstances in which *P. ananatis* is pathogenic and in its ability to be transferred to a suitable environment for establishment.

6.1.2 Hazard identification: quarantine pest status

Pantoea ananatis meets the criteria to be a quarantine pest for New Zealand.

Pantoea ananatis is not known to be present in New Zealand:

- It is recorded as absent in NZFungi2 (2019) and is not recorded in PPIN (2019).
- The regulatory status of *P. ananatis* is recorded as ‘regulated’ in BRAD.

There is the potential for *P. ananatis* to establish in New Zealand due to the favourable climatic conditions, host and potential vector availability:

- *Pantoea ananatis* has a world-wide distribution:
    - It has been reported from parts of Asia, Africa, North America, Central America and the Caribbean, South America, Europe and parts of Oceania (CABI 2018a).
- The global distribution of *P. ananatis* includes countries with a similar climate to New Zealand: Italy (CMI 0.8–0.9), Poland (CMI 0.8–0.9) and USA (CMI 0.7-0.8) (Phillips et al, 2018).
- *Pantoea ananatis* inhabits a wide range of ecological niches.

- The bacterium has a broad host range including maize, onions and eucalyptus, which are commonly grown in New Zealand.
- Two species of thrips, *Thrips tabaci* and *Frankliniella fusca*, have been reported to be associated with transmission of *P. ananatis* (Gitaitis et al, 2003; Dutta et al, 2014). *Thrips tabaci* is present in New Zealand, but *F. fusca* is not (NZOR, 2019). No plant species in the family Zingiberaceae are listed as host plants of *T. tabaci* in CABI (2018b), and no reports in other literature were found of plants in this family as hosts of *T. tabaci*.
- The closely related bacterium *P. agglomerans*, which is biologically similar to *P. ananatis* (Coutinho and Venter, 2009), is established in New Zealand (NZFungi2, 2019).

There is potential for *P. ananatis* to have impacts on plants of importance to New Zealand:

- As a pathogen *P. ananatis* is associated with sporadic disease outbreaks, causing severe economic losses in some cases (Coutinho and Venter, 2009).
- Isolates of *P. ananatis* from various hosts have been shown to be pathogenic to onions (Kido et al, 2010; Romberg et al, 2013).
- The onion industry in Georgia (USA) reported 25-100% losses for growers in 1997, due to *P. ananatis*, as well as 10% pre- and post-harvest yield losses between 1998 and 2001 (Gitaitis and Gay, 1997). Onions are the 6th most valued horticultural export for New Zealand. Exports are valued at $112 million and the domestic market at $30 million (FreshFacts, 2017).
- Romberg et al (2013) isolated *P. ananatis* from symptomatic *Dracaena reflexa* plants in PEQ. *Dracaena* spp. are not known hosts of *P. ananatis*. These isolates of *P. ananatis* were able to induce symptoms on onion bulb tissue in pathogenicity tests. This observation, as well as the work by Kido et al (2010), suggests that *P. ananatis* associated with ginger has the potential to induce disease in other hosts.
- *Pantoea ananatis* has an opportunistic nature. Disease severity on the different hosts of the pathogen is influenced by environmental conditions (Coutinho and Venter, 2009). Disease outbreaks on rice have been reported from Northern Italy (CMI 0.8) and soft rot of onion described in Georgia, USA (CMI 0.8-0.7). This suggests that the climate in New Zealand is suitable to support disease expression. However, other environmental factors, such as water availability, are also likely to influence disease expression. This makes predicting the environmental suitability of New Zealand to support disease expression *of P. ananatis*, without relevant models, difficult.
- The varied nature of the bacterium, and the influence of environmental conditions, makes it difficult to predict how *P. ananatis* would behave were it to enter New Zealand on ginger rhizomes.
- The high genetic diversity within the species *P. ananatis* is beginning to be understood (Weller-Stuart et al, 2017). This genetic diversity is likely to be responsible for the wide host range and suggests that the full capacity of the bacterium to infect different hosts is as yet unknown.
- *Pantoea ananatis* has not been reported as having impacts in natural ecosystems.

6.1.3 Hazard identification: commodity association

Pantoea ananatis is associated with rhizomes of *Zingiber officinale* (ginger) in countries within the scope of this IRA:

Pantoea ananatis is associated with ginger rhizomes.

- *Pantoea ananatis* has been reported causing foliar blighting of ginger in India; a 10% reduction in rhizome yield was observed (Dohroo et al, 2013 (abstract)).
    - Colonies of *P. ananatis* were isolated from the symptomatic leaves. The appearance of the rhizomes was not described and no attempt to isolate the bacterium from the rhizome was made (Dohroo et al, 2013 (absctract)).
- Carr et al (2013) demonstrated that following artificial inoculation of onion leaves, disease symptoms were visible in the onion bulbs 46-52 days post inoculation. *Pantoea ananatis* was recovered from the bulb lesions. This suggests that infection of one plant part can result in infection of other parts of the plant. ginger leaves by *P. ananatis* would result in the bacterium being present in the rhizome.
- Chen et al (2014) isolated the total endophytic population from roots, stems, tubers and leaves of surfaced sterilised, in-field grown ginger plants. The plants were all healthy and collected from the same field in Shangdong Province, China. *Pantoea ananatis* was identified, by sequence analysis, from plants during the 'stem and leaf vigorous growth stage'. It was not isolated from any part of the plant during the 'tuber enlargement stage' (Chen et al, 2014).
- Edelman and Lin (2014) isolated *Pantoea* sp. from ginger rhizome flesh. The ginger used in the study was purchased at local markets and it is not known which country or countries the ginger originated from (Edelman and Lin, 2014).

Pantoea ananatis occurs in countries within the scope of this IHS, although records have not been found of it associated with symptoms in these countries.

- *Pantoea ananatis* has been reported from China (Yan et al, 2010).
    - The main ginger growing region in China is Shandong province (agri.gov.cn). *Pantoea ananatis* is reported from this region (CABI 2018a).
    - As stated above, Chen et al. (2014) identified *P. ananatis* via sequence analysis of healthy ginger rhizomes in Shandong province.
    - No information could be found detailing the environmental conditions required for infection of ginger by *P. ananatis*. On onions, another root crop, disease occurs under wet conditions and temperature between 28 and 35°C (Schwartz et al, 2003). The optimal temperature for ginger growth is between 25 and 29°C, within the range for *P. ananatis* infection. Average monthly temperatures for Shangdong region are within this range during the ginger growing season May to October. However, unlike onions which are harvested during the rainy season (May-September) (MPI, 2009), ginger is harvested from October-February (when precipitation is low). Therefore, the environmental conditions may not support *P. ananatis* infection of ginger.
- *Pantoea ananatis* has been reported from Australia (Cother et al, 2004).
    - In Australia, the largest ginger producing region is Queensland (Camacho and Brescia 2009), which reaches high temperatures and humidity, as well as having high summer rainfall (Camacho and Brescia 2009).

- *Pantoea ananatis* has been reported causing disease on pineapple in Queensland (Bradley, 1986). The high average monthly temperatures during the ginger growing season (26-29°C) and the high summer rainfall, including during the harvest period which starts in February, means that the environmental conditions may support *P. ananatis* infection, based on data for onions (BOM.GOV.AU; Camacho and Brescia 2009).
- There are no reports of symptoms on ginger caused by *P. ananatis* in countries where we import ginger from.

6.1.4 Assessment against criteria for requiring additional measures

The criteria for a pest or pathogen to require measures beyond the minimum requirements for the commodity are a combination of the likelihood of the pests being removed or detected and the risk if they are not. The risk assessment first considers how likely the pest or pathogen is to be managed by the minimum requirements, based on its biological traits. Pests and pathogens which are unlikely to be removed from the rhizomes by post-harvest handling and processing or be detected by inspection at the border undergo further risk assessment.

The proposed minimum risk management requirements for the import of fresh ginger include commercial cultivation methods, visual inspections for disease symptoms and ensuring that the rhizomes are free from soil and other contaminants, damage and defects. Therefore the minimum requirements may not manage pathogens which can cause latent or asymptomatic infection in the rhizomes (and roots for *Z. zerumbet*).

Pantoea ananatis may not be detected by visual inspection or affected by other aspects of the minimum requirements:

- Grading and sorting should remove damaged or secondary infected rhizomes (MPI, 2009)
- Visual inspection would not be sufficient for asymptomatic or endophytically infected ginger. But there is little evidence of this in ginger rhizomes.
- In onions, bulbs that are only infected with *P. ananatis* display little or no external symptoms. Such onions are unlikely to be removed during grading and therefore will be packed and shipped (Carr et al, 2013).
- Commercial production practices are unlikely to have any influence on *P. ananatis* infection as it is not recorded as causing disease on ginger crops in countries within the scope of the IRA.

Pantoea ananatis is a significant pathogen in different parts of the world*:*

- There is limited literature about *P. ananatis* as pathogen of ginger (Dohroo et al, 2013).
- There is one report of *P. ananatis* as an endophyte of ginger and one study identified *Pantoea* sp. as a ginger rhizome endophyte (Chen et al, 2014; Edelman and Lin; 2014).
- There is significant literature available describing *P. ananatis* as a pathogen of other crops: onion (Gitaitis and Gay, 1997; Goszczynska, 2006), rice (Cother et al,

2004; Cortesi and Pizzatti, 2007), eucalyptus (De Maayer et al, 2010; Coutinho et al, 2002), maize (Paccola-Meirelles et al, 2010).
- *Pantoea ananatis* is an emerging pathogen. Since 1983 the host range and geographic range of diseases attributed to *P. ananatis* has significantly increased (Coutinho and Venter, 2009).
- A number of genome sequences of *P. ananatis* have been published and there is recent research on the pathogen (De Maayer et al, 2014; Sheibani-Tezerji et al, 2015). Recent work is focusing on utilising molecular methods to understand the pathogenicity and diversity of the bacterial species (Weller-Stuart et al, 2017).
- The current consensus of the literature is that further work is needed to understand the genetic basis of the different characteristics of *P. ananatis.* As well as the potential influence of environmental conditions on causing the bacterium to enter a pathogenic life stage.

The exposure (or transfer) of *P. ananatis* to a suitable environment for establishment is likely to be a limiting factor for establishment.
- Ginger rhizomes generate a small volume of waste compared to other fresh produce commodities. Ginger is not consumed in large amounts and all parts can be used.
- *Pantoea ananatis* associated with discarded ginger is not likely to come into contact with ginger plants. However, from how various isolates of *P. ananatis* have been demonstrated to interact with different hosts, *P. ananatis* associated with ginger rhizomes is likely to affect other host plants.

There is significant uncertainty regarding the circumstances in which *P. ananatis* is pathogenic.
- *Pantoea ananatis* has been reported from China and Australia, however ginger disease caused by the pathogen has not been reported from these countries. The varied nature of the bacterium and the influence of environmental conditions make it very difficult to assess how *P. ananatis* would behave were it to enter New Zealand on ginger rhizomes.
- It is uncertain why *P. ananatis* is pathogenic in some circumstances and not others.
    - *Pantoea ananatis* is described as an endophyte, epiphyte, pathogen and symbiont (Coutinho et al, 2009). The bacterium has also has also been found as a saprophyte in numerous environments (Weller-Stuart et al, 2017). Different strains of *P. ananatis* have been predicted in the literature, but none have been formally described (Kido et al, 2010).

Conclusion
- *Pantoea ananatis* may not be detected by visual inspection or affected by other aspects of the minimum requirements
- *Pantoea ananatis* is a significant pathogen in different parts of the world.
- The exposure (or transfer) of *P. ananatis* to a suitable environment for establishment is likely to be a limiting factor for establishment.
- There is significant uncertainty regarding the circumstances in which *P. ananatis* is pathogenic.In addition, as stated in the summary of taxonomy and pathogenicity in

section 6.1, there is uncertain in the assessment due to the extreme variation in the species.

6.1.5 References

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6.2 Other bacteria (including phytoplasmas)

The phytoplasma '*Candidatus* Phytoplasma asteris' (synonym tomato big bud phytoplasma) causes big bud of ginger, described as occurring sporadically in Australia (Persley *et al.* 2010). Phytoplasmas are generally transmitted by insect vectors. Therefore, the main risk of establishment of a phytoplasma from ginger comes from propagation of an infected rhizome and then transmission by a vector to a suitable host. After considering the likelihood of unintended propagation in section 2.2, phytoplasmas were not assessed further.

Appendix 1 (Section 8) lists the potential bacterium hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following bacteria were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Family	Organism	Reason not requiring further assessment
Ralstoniaceae	*Ralstonia solanacearum* Race 4 (Smith 1896) Yabuuchi et al, 1996 (Recently this taxon was reclassified as *R. syzygii*.)*	Is only reported to affect Zingiberaceae and Costaceae in tropical regions (Paret *et al.* 2008, Kumar *et al.* 2014). The host range and geographic distribution make it unlikely that *R. solanacearum* race 4 would establish in New Zealand or cause significant impact. Rhizomes from plants affected by *R. solanacearum* race 4 are generally darker than normal and have water-soaked areas with pockets of milky fluid (Persley *et al.* 2010). Such symptoms are likely to be visible during inspection and rhizomes with signs of disease symptoms, defects and damage are excluded by the commodity definition.
Xanthomonadaceae	*Xanthomonas campestris* pv. *zingibericola* (Ren and Fang, 1981) Bradbury, 1986 synonym: *Xanthomonas zingibericola* Ren and Fang, 1981	There is little information available on this bacterium. It is described causing a 'specific' leaf spot of ginger, presumably meaning that the pathogen only affects *Zingiber* spp. (Weiss 2002). The lack of information indicates that it is not an important pathogen. This coupled with the apparent specificity to *Zingiber* spp. indicates that the likelihood of the bacteria causing significant impacts to New Zealand are very low. It was therefore excluded from further consideration.
Xanthomonadaceae	*Xanthomonas zingiberi* (Uyeda) Savulescu, 1947	There is very little information available on this bacterium. It is known to occur in ginger rhizomes (Wang *et al.* 2003). Symptoms associated with the pathogen are not known. No information could be found that is has been isolated from any other host. The lack of information indicates that it is not an important pathogen. This coupled with the apparent specificity to ginger indicates that the likelihood of the bacteria causing significant impacts to New Zealand are very low. It was therefore excluded from further consideration.

* The taxonomy of *Ralstonia solanacearum* is complex. Until Safni *et al.* (2014) proposed three separate species of *Ralstonia,* the convention was to use the 'race' system of bacterial classification. Due to the recent change, the literature found in reference to *Ralstonia* on ginger used the race classification. In the literature the references found describing *Ralstonia* causing disease of ginger related to race 3 and race 4 (Persley *et al.* 2010). No records of any other races of *Ralstonia* affecting were found and therefore were not considered in the assessment for ginger.

Recently the regulatory system in BORIC was altered to match the change in taxonomy of *Ralstonia*. *Ralstonia solanacearum* (previously *R. solanacearum* race 2 and *R. solanacearum* race 3) is non-regulated in BORIC and recorded as present in NZFUNGI2 database. *Ralstonia solanaceraum* race 4 is now called *R. syzygii* (with 3 subspecies); in NZFUNGI2, *R. syzygii* and the 3 subspecies are recorded as absent. In BORIC strains of *R. solanacearum* not present in New Zealand are considered 'regulated'. Therefore, all subspecies of *R. syzygii* (*R. solanacearum* race 4) are considered absent from New Zealand and regulated in BORIC.

6.2.1 References

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7 Other pest and pathogen groups

The nematode *Pratylenchus zeae* and the bacterium *Pantoea ananatis* were considered the only hazards to require further assessment (targeted PRAs) to determine if they meet the criteria for requiring measures beyond minimum requirements. The following organisms were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project..

7.1 Fungi

Many fungi were found to be associated with ginger. Those found to cause leaf and stem diseases were considered to not be associated with rhizomes and were not considered for further assessment. A large group of fungi were identified as causing rot of ginger rhizomes both in the field and post-harvest and were described as causing obvious, visible symptoms on diseased rhizomes (Dohroo 2016, Yang *et al.* 1988), which would be detected during inspection.

Appendix 1 (Section 8) lists the potential fungus hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following fungi were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project

Family	**Organism**	**Reason not requiring further assessment**
Aspergillaceae	*Aspergillus parvisclerotigenus* (Mich. Saito & Tsuruta) Frisvad & Samson (2005)	The fungus has been reported to cause post-harvest rot of *Z. officinale* rhizomes (Akhar *et al.* 2014). However, there is no report of the fungus being present in any of the countries being considered for export. Therefore *A. parvisclerotigenus* was excluded from further assessment.
Botryosphaeriaceae	*Phyllosticta zingiberi* syn. *Phoma zingiberis* T.S. Ramakrishnan 1942	The fungus causes leaf spot disease on host plants (Farr & Rossman, accessed March 2019). Therefore is unlikely to be associated with ginger rhizomes and was excluded from further assessment.
Glomerellaceae	*Glomerella cingulata* (anamorph *Colletotrichum gloeosporioides*) Spaulding & H. Schrenk 1903	*Glomerella cingulata* is regulated on the basis of ‘strains in New Zealand’ and ‘strains not in New Zealand’. It is noted in BRAD (accessed March 2019) that on logan, litchi, mangosteen, durian and ginger the fungus is non-regulated as no strains have been found associated with these hosts. Therefore, *G. cingulata* was not considered for further assessment.
Mucoraceae	*Mucor racemosus* Fresen. 1850 synonym: *Mucor oudemansii* Váňová, 1991	The fungus causes rotting of ginger rhizomes in storage (Dohroo 2016). It is therefore likely that diseased rhizomes would be visible during inspection. Symptoms of infection are likely to be visible during inspection and therefore not require measures beyond the minimum requirements.
Nectriaceae	*Fusarium oxysporum* f. sp. *zingiberi* Trujillo, 1963	*Fusarium oxysporum* f. sp. *zingiberi* causes Fusarium yellows of ginger plants (Dohroo 2016). The infected plants appear yellow, stunted and the rhizomes are shrivelled. The fungus has also been reported to cause rhizome rot during storage (Xizhen *et al.* 2016, Dohroo 2016). It is therefore likely that diseased

		rhizomes would be visible during inspection. Symptoms of infection are likely to be visible during inspection and therefore not require measures beyond the minimum requirements.
Physalacriaceae	*Armillaria mellea* (anamorph *Rhizomorpha subcoticalis*) (Vahl) Kummer 1871	*Zingiber officinale* is reported as a host of *A. mellea* in Australia (DAWR 2013), but this is likely to be a misidentification. *Armillaria mellea* is a root pathogen, but it is typically associated with hardwood trees and conifers a well as decaying wood. The fungus is therefore unlikely to be associated with fresh ginger and it is excluded from further assessment.
Pyriculariaceae	*Pyricularia zingiberi* syn. *Proxipyricularia zingiberis* Klaubauf et al 2014 (preferred name)	The primary host plants are *Z. officinale* and *Z. mioga* and no information could be found suggesting it affects other host plants. The fungus causes leaf spot/leaf blast on *Z. officinale* (Farr & Rossman – accessed March 2019, Abed-Ashtiani 2016) and black scabs on rhizomes (Kotani & Kurata 1992). The obvious symptoms on rhizomes and the restricted host range means that *P. zingiberis* is unlikely to meet the criteria for measures beyond the minimum requirements.
Xylariaceae	*Rosellinia bunodes* (Berkeley & Broome) Saccardo 1882	The fungus causes black rot of ginger (Dohroo 2016). The disease commonly occurs in Jamaica and the Philippines (Dohroo 2016). The fungus also occurs in countries where ginger is imported from (Farr & Rossman, accessed March 2019). Symptoms of infection are likely to be visible during inspection and therefore not meet the criteria for measures beyond the minimum requirements.

7.1.1 References

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7.2 Oomycetes

A number of oomycetes were identified as causing rot of ginger rhizomes both in the field and post-harvest and were described as causing obvious, visible symptoms on diseased rhizomes (Dohroo 2016, Aitken *et al.* 2015, Li *et al.* 2015, Yang *et al.* 1988), which would be detected during inspection.

Appendix 1 (Section 8) lists the potential oomycete hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following oomycetes were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Family	Organism	Reason not requiring further assessment
Pythiaceae	*Pythium aphanidermatum* Fitzpatrick 1923 and *Pythium deliense* Meurs 1934	*Pythium aphanidermatum* causes soft rot and the formation of brown spots of rhizomes, as well as leaf/stem symptoms (Li *et al.* 2014, Le *et al.* 2016). Young sprouts are susceptible, with rot spreading to the rhizome (Dohroo 2016). The pathogen has an optimal growth temperature of 32-40°C (Al-Sheikh 2010) and therefore is unlikely to thrive in the New Zealand climate. The described symptoms are likely to be visible during inspection and is therefore unlikely to meet the criteria for measures beyond the minimum requirements. *Pythium deliense* has been described on *Z. officinale* causing obvious post-harvest rot of the rhizomes (Aitken *et al.* 2015, Dohroo 2016) and soft rot of rhizomes in the field (Le *et al.* 2016). The described symptoms were visibly obvious and would be detectable during inspection and is

		therefore unlikely to meet the criteria for measures beyond the minimum requirements.
Pythiogetonaceae	*Pythiogeton ramosum* Minden 1916	*P. ramosum* causes soft rot of ginger and is newly described as a pathogen of *Z. officinale* in Australia (Aitken *et al.* 2015). It was isolated from rhizomes with visible rot symptoms (Le *et al.* 2015). The visibly apparent symptoms on rhizomes means that *P. ramosum* is unlikely to meet the criteria for measures beyond the minimum requirements.

7.2.1 References

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7.3 Insects – Coleoptera (beetles)

Appendix 1 (Section 8) lists the potential beetle hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following beetles were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Family	Organism	Reason for no further assessment
Anthicidae	*Anthicus* sp.	A genus of antlike flower beetles (EOL – accessed 29 Mar 2019). About 20 species in the genus listed as stored product pests (Hagstrum & Subramanyam 2016), including one, *A. hesperi*, present in New Zealand (NZOR – accessed 29 Mar 2019). Two records of interceptions on ginger at the New Zealand border up until January 2019 (LIMS). Little information available about these beetles, suggesting they are not significant pests, at least outside of stored products. Potential to be associated with ginger as stored product pest. These beetles have biological traits which indicate it is likely to be managed by minimum requirements. Unlikely to have a significant impact in New Zealand.
Carabidae	*Abacetus* sp.	Carabids are typically predaceous and highly unlikely to be associated with imported ginger rhizome.
Chrysomelidae	*Chaeridiona mayuri*	First described in India in 2014, infesting ginger and turmeric; adults and larva (leafminers) feed on leaves (Shameem & Prathapan 2014). So, appears only known from India, and feeding habits suggest it is highly unlikely to be associated with imported ginger rhizome.
Curculionidae	*Caulophilus oryzae* (broad nosed grain weevil)	Found in the West Indies, Central America, and North America; found in the seeds of a range of cereals in the field and in storage, and occasionally on some fruit, nut and root crops; mining of seeds, rhizomes and roots by larvae is evident; immature stages (larvae, pupae) can be dispersed within cereal grains, and to a much lesser extent in the roots of other crops; has been recorded in the rhizomes of stored ginger in the West Indies (CPC 2018a). Distribution: USA (restricted), Central America, West Indies (Rees 2004). So, may be associated with ginger rhizome as a stored product pest, but not known to be present in countries we will import ginger from.
Curculionidae	*Elytroteinus subtruncatus* (Syn. *E. geophilus*) (Fijian ginger weevil)	Believed to be endemic to the Austro-Malayan subregion, this weevil is present on several Pacific islands including the Cook Islands, Fiji, Hawaii, New Zealand [not present in New Zealand - may have been taken from interception data], Samoa, Tahiti and Tutuila; first found in Hawaii in white ginger roots (*Hedychium coronarium*), since then it

		has been reported on avocado seed, bird-of-paradise tubers (*Strelitzia reginae*), cycad trunk, lemons, Marrattia fern, sugarcane, taro roots, and ti cuttings (*Cordyline terminalis*); larvae burrow into the root, corm, or tuber of the growing host plant (Mau & Kessing 1992). DAWR (2013) assessed the risk of *E. subtruncatus* on ginger from Fiji: some of the reported host records are 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; female lays a single egg in the corms, tubers, fruits or soft stems of a range of plants; damage can be recognised by stem holes, filled with black powdery matter and frass; affected ginger rhizomes may show external signs of rot; endemic to a small number of countries in the South Pacific, also present in Hawaii and may have been introduced there; recent references are scarce, suggesting it is not a major pest; probability of entry into Australia on ginger from Fiji estimated as 'high', but probability of entry, establishment and spread considered 'low', and potential consequences estimated as 'very low'; unrestricted risk considered 'negligible'. There are 16 records of interceptions of *E. subtruncatus*, and one of *Elytroteinus sp.*, on ginger at the New Zealand border up until January 2019 (LIMS). So, may be associated with ginger rhizome imported from countries in which the beetle is present but has biological traits which indicate it is likely to be managed by minimum requirements. The current distribution has a poor climate match with New Zealand, indicating thatestablishment in New Zealand is unlikely, although there are hosts or potential hosts present in New Zealand.
Elateridae	*Drasterius* sp.	Elaterid larvae live in the soil; some are predaceous, others feed on decaying vegetation and plant roots; they are mobile and can travel from plant to plant, tending to follow pre-existing burrows; adults live above ground and feed on nectar, pollen, flowers and sometimes soft-bodied insects like aphids (TERRAIN 2018). There have been 3 interceptions (LIMS) of elaterid adults (only identified to family) on ginger from

		Thailand, presumably acting as stored product pests or just an incidental association. Larvae that feed on roots are external feeders (at least information about their feeding habits suggests so) and unlikely to be associated with clean, dry imported ginger rhizomes. Adults associated with imported ginger should be detected by inspection.
Erotylidae	*Dacne* sp.	Very little literature found about beetles in the genus *Dacne*. Larvae and adults of beetles in the family Erotylidae (pleasing fungus beetles) feed on the fruiting bodies of fungi growing in decayed wood (BugGuide 2015a). Each pleasing fungus beetle species seems specific to a certain group of fungi; some that feed on fungi edible by humans are considered pests in Asia (Skelley 2014). Unlikely to be associated with ginger rhizome meeting the commodity definition.
Latridiidae	*Corticaria* sp.	Little literature found about the biology and ecology of beetles in the genus *Corticaria*. Latridiidae (minute brown scavenger beetles) feed on rotting vegetable matter; some species live in houses on damp wallpaper, mouldy bread, etc. or otherwise associated with stored products (BugGuide 2015b). One interception record (LIMS) for *Corticaria* sp. of an adult on ginger from Australia. Potential to be associated with ginger as stored product pest, particularly if decaying material is present. Has biological traits indicating it is likely to be managed by the minimum requirements).
Mycetophagidae	*Litargus* sp.	Little literature found about the biology and ecology of beetles in the genus *Litargus*. Larvae and adults of beetles in the family Mycetophagidae live in decaying leaf litter, fungi and under bark; most species feed on fungi (Wikipedia 2018). There has been one interception of *Litargus* sp. on ginger from Australia (LIMS). Potential to be associated with ginger as stored product pest if decaying material is present. Has biological traits indicating it is likely to be managed by the minimum requirements).
Nitidulidae	*Haptoncus ocularis*	Prior to modern global transportation systems this species was typically found in South-east Asia, parts of the Orient, the Indian subcontinent and some tropical areas of Africa. Over the last 2 decades it has become one of the most pervasive

		sap beetles in the world, spreading in more temperate climates like Europe; recently discovered in USA - unlikely to pose a serious threat to agricultural commodities in continental USA, it may become a nuisance pest (Cline & Audisio 2011). Mostly attack ripening and fallen fruits (Jelinek *et al.* 2016). Has been intercepted as an adult on ginger (LIMS). Potential to be associated with ginger as stored product pest, particularly if decaying material is present. Has biological traits indicating it is likely to be managed by the minimum requirements. Unlikely to have a significant impact if it established in New Zealand.
Ptiliidae	*Acrotrichis flavipennis*	Very little information found about this species. The 35+ North and Central American species in the genus *Acrotrichis* have been found in leaf litter, mammal nests, dung, and decaying fungi (BugGuide 2012). Family Ptiliidae: larvae and adults feed on moulds and fungi (BugGuide 2015c). Potential to be associated with ginger as stored product pest if decaying material is present. Unlikely to be associated with ginger rhizome which meets the commodity definition.
Scarabaeidae	*Adoretus sinicus* (Chinese rose beetle)	Polyphagous beetle, native to parts of eastern Asia, which has been introduced (probably via the plant trade) widely throughout much of Southeast Asia and many Pacific islands, and has the potential to spread further; it feeds on a broad range of plants and can cause severe damage to crops, ornamental plants and trees in places where it has been introduced; adults feed on foliage, larvae live in rich soil, leaf litter, decaying vegetation, or compost, and feed on humus and detritus rather than living plant tissue according Williams (1931, in CPC 2018b), though Bhawane *et al.* (2012, in CPC 2018b) say that they feed on seedlings; eggs and larvae may be easily transported with cultivated plants in soil or roots, though pests usually visible to the naked eye (CPC 2018b). Feeding habits suggest it is unlikely to be associated with imported ginger rhizome conforming to the commodity definition, and that it would be visually detectable if it was.
Scarabaeidae	*Adoretus versutus* (compressed beetle)	Adults feed on ginger leaves; eggs may be present in the soil, and larvae may feed on roots of some host plants, but association with ginger rhizomes is not reported (DAWR 2013). There is insufficient

		evidence to consider it associated with ginger rhizome.
Scarabaeidae	*Brahmina coriacea*	Distribution - India (CPC 2017). Both adults [above ground] and grubs [below ground] are polyphagous pests; apple and walnut are the preferred hosts of adults, potato is severely affected by grubs (Pathania & Chandel 2017). No evidence this beetle is distributed outside of India, and larvae are presumably external feeders and while they may be in soil around ginger roots are unlikely be present on imported clean, dry ginger rhizome.
Scarabaeidae	*Phyllophaga* spp.	Adults of this genus feed on foliage, larvae are subterranean and feed on roots and decaying foliage (BugGuide 2018). Scarab larvae are generally large and feed externally on roots; unlikely to be associated with ginger rhizome which meets the commodity definition.
Scarabeidae	*Protaetia* sp.	Scarab beetles in the subfamily Cetoniinae (flower chafers); many Cetoniine larvae (which are subterranean like other scarabs) are not plant pests but subsist on organic soil debris and compost (Dunlap *et al.* 2016a). *Protaetia* species adults are generalists, feeding upon the nectar, pollen, fruit, and sap of a number of plant species (Dunlap *et al.* 2016b). There is one interception record for a Protaetia sp. adult on ginger from Thailand (LIMS). Given the feeding habits of *Protaetia* adults this is unlikely to be a biological association. Feeding habits suggest *Protaetia* species are unlikely to be associated with imported ginger rhizome conforming to the commodity definition; they are likely to be visually detectable if they were.
Staphylinidae	*Carpelimus* sp.	Majority of the species in the genus inhabit damp ground on the supralittoral/periaquatic situations (BugGuide 2014, Gildenkov 2014). Probably all feed on algae [not clear whether this refers to European or all *Carpelimus*] (Beetle Europe 2013). Little information about the genus; no evidence any are significant pests. One interception of an adult on ginger from Australia (LIMS). Given the known feeding habits of *Carpelimus* species this is unlikely to be a biological association. Known feeding habits suggest *Carpelimus* species are unlikely to be associated with imported ginger

		rhizome conforming to the commodity definition; they are likely to be visually detectable if they were.
Staphylinidae	*Phloeonomus* sp.	Found under bark, sometimes associated with bark beetles (BugGuide 2013). Little information on the genus; nothing suggesting any is a significant pest. One record of an adult *Phloeonomus* sp. adult interception on ginger from Australia (LIMS). Little information found about this genus, but if they are generally found under bark, this is unlikely to be a biological association. Known feeding habits suggest *Phloeonomus* species are unlikely to be associated with imported ginger rhizome conforming to the commodity definition; they are likely to be visually detectable if they were. Unlikely to have a significant impact if they established in New Zealand.
Staphylinidae	*Scaphisoma distans*	Distribution: Fiji (Löbl 1980). A Melanesian species, and present in the Philippines (Löbl & Ogawa 2016). Genus Scaphisoma: small mycophagous beetles (Löbl & Ogawa 2016); associated with various fungi, especially polypores (BugGuide 2017). Potential to be associated with ginger as stored product pest if decaying material is present. Unlikely to be associated with imported ginger rhizome meeting the commodity definition; they are likely to be visually detectable if they were.). Unlikely to have a significant impact if it established in New Zealand.
Staphylinidae	*Tachinus* sp.	*Tachinus* species are often found in decaying organic materials such as dung, rotting mushrooms, carrion and compost, although some species are found in leaf litter and moist debris near streams, often in cool, shaded sites (Webster *et al.* 2012). No mention of feeding habits found, other than a mention of *T. rufipes* as a predator generally found in “damp (but not wet) habitats, damp logs, matted vegetation, compost and even dung” (Nature spot – accessed 4 Apr 2019). It seems likely, based on the above information, that most *Tachinus* species would either be predators in damp habitats, or detritus/fungus feeders in such habitats. No evidence that there are significant pests in the genus. Two interception records on ginger from Australia for *Tachinus* sp. – one larva, one adult – (LIMS). Although there is uncertainty about the feeding habits of *Tachinus* species, it is possible they could

		be associated with ginger as stored product pest if decaying material is present. Unlikely to be associated with imported ginger rhizome meeting the commodity definition; they are likely to be visually detectable if they were.. Unlikely to have a significant impact if they established in New Zealand.

7.3.1 References

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7.4 Insects – Diptera (flies)

Flies associated with the ginger rhizome are typically found there in conjunction with a fungal or bacterial infection. Infected ginger plants seem to be more attractive to flies for oviposition and fly larvae which bore into the rhizome. Formerly, some flies were considered primary pests of ginger but subsequent research has shown them to be mostly secondary pests.

Appendix 1 (Section 8) lists the potential fly hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following flies were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Family	Organism	Reason for no further assessment
Chloropidae	*Chalcidomyia atricornis* (Meigen, 1838) and *Merochlorops flavipes* (Malloch, 1927)	'Grass flies/frit flies' (family Chloropidae) are often very small, between 1–5mm and rarely 6mm–9mm and 12 mm long. They are yellow or black and shiny. Common in grassy areas but can be found in a variety habitats. The larvae of most species feed on grass stems (Poaceae, Cyperaceae, Typhaceae). Some are pests of cereals, some are saprophages, scavengers, parasites, predators (BugGuide 2017a). Information specific to *C. atricornis* was not found in the usual searches. Maggots have been recorded on ginger rhizomes in India though it is highly likely the rhizomes were diseased based on the commentary in Ravindran & Nirmal Babu (2004). *Merochlorops flavipes* (synonym *Formosina flavipes* Malloch) is recorded from ginger rhizome in India. Various species of dipteran maggots bore into rhizomes and roots, and they are generally seen in plants affected by rhizome rot disease. In one study healthy rhizomes had no maggots, another study showed clearly that maggots could only infest diseased rhizomes and cannot be considered as a primary pest of the crop (in Ravindran & Nirmal Babu 2004) It is unlikely to be associated with ginger rhizomes which meet the commodity definition..
Drosophilidae	*Dettopsomyia nigrovittata* Malloch, 1824	This species is reported from Australia, Brazil, India and Japan (MPI Hort. Imports). There is one record of an interception on ginger at the border. Drosphilids are fruit flies or vinegar flies which are generally associated with over-ripe and decaying produce and usually considered nuisance flies. There are a couple of known pests in the family – *Drosophila suzukii* (berry fruit) and *Zaprionus indianus* (figs). Some members in the family can spread bacteria (BugGuide 2014).

		They are unlikely to be associated with ginger rhizomes which meet the commodity definition..
Limoniidae	*Limonia strigivena* (Walker, 1861)	"Stout (1982, page 651) records this species as having no information and was probably recorded from a rotting rhizome. It was considered to be of no quarantine significance. This was also the opinion of DAFF (2012)" (Crosby 2013). Limoniids are short-palped crane flies. The larvae are found in a range of habitats from lowlands to alpine. They are restricted to moist environments such as saturated soil, under mosses and liverworts, within decaying and rotting vegetation, and so on, while some are properly aquatic. The adults prefer to rest in dark shady areas during the day and are generally most active during twilight. Some have the peculiar habit of hanging from spider webs (Insects of Tasmania: Diptera, accessed Jan 2019) A host association for *L. strigivena* and ginger rhizomes was not found. It is unlikely to be associated with rhizomes that meet the commodity definition.
Micropezidae	*Calobata indica* (Maxwell-Lefroy and Howlett, 1909) and *Mimegralla coeruleifrons* (Macquart, 1843) and *Mimegralla* sp. nr *coeruleifrons*	Family Micropezidae is not known to occur in New Zealand (Gordon 2010; NZOR – accessed 18 Jan 2019). This Family are stilt-legged flies/small-footed flies and are between 3mm-16mm long. Adults of some species are attracted to rotting fruit/dung. In other species the adults are predacious. Larvae are saprophagous. They are found worldwide with greater diversity in the tropics compared to cooler climes (BugGuide 2019). *Calobata indica* is reported from India. The larvae of *C. indica* have often been found in diseased ginger rhizomes (Ravindran & Nirmal Babu 2004) so should not be present in rhizomes that meet the commodity definition. *Mimegralla coeruleifrons* is a recognised pest of ginger and turmeric in India. It is known as a rhizome fly. Adults are between 11–13.6mm long, larvae range from 0.6–8mm long and eggs are about 0.75 long. The female lays eggs in soil and the larvae feed on rhizomes. Initially it was thought the larvae damaged the rhizomes and introduced bacteria and fungi, however, controlled experiments in various combinations clearly indicated that the larvae could infest only diseased ginger rhizomes and cannot be considered a primary pest of the crop

		(Koya 1990, in Ravindran & Nirmal Babu 2004). Based on Koya 1990, *M. coeruleifrons* is unlikely to be associated with rhizomes that meet the commodity description. However, based on Sandya (2015) there is the potential for healthy rhizomes to be attacked by larvae. The damage is expected to be visible and damaged rhizomes will not meet the commodity definition. Sandhya (2015) reported *M*. sp. nr *coeruleifrons* on ginger rhizomes in India. She comments that the identity is not entirely clear, this species may be the *M. coeruleifrons* infesting ginger "further north" [in India]. Sandya (2015) noted that the females tend to oviposit near or on diseased rhizomes. From a range of experiments she concluded that a recovery of 70% maggots from diseased plants indicated that the maggots were secondary in nature to the disease, not the causal agent. However, she also noted that a recovery of 42% maggots from healthy rhizomes indicated the capacity of the fly to be a pest of ginger. Because the maggots tunnel into ginger rhizomes it is likely damage will be visible, and infested rhizomes would not meet the commodity definition..
Muscidae	*Atherigona orientalis* Schiner, 1868	*Atherigona orientalis* is a tropical – subtropical pest of fruit and of human health. It is present in Fiji, Samoa, Vanuatu, PNG, Australia, China, Thailand (MPI Hort. Imports). "This fly is highly polyphagous. Larvae feed and develop on live and decaying plant material, faeces, carrion and even the live larvae of other insects including the tobacco caterpillar (*Spodoptera litura* Fabricius). Eggs are laid in cracks of splitting ripe to rotting fruit, in oviposition sites of other insects and even in carrion or faeces, as females do not possess a sharp, strong ovipositor able to puncture hard tissues. It is suspected that the larvae of *A. orientalis* feed on the larvae of *Bactrocera* spp. (Uchida *et al.* 2006) and *Dacus* spp. (Skidmore 1985) fruit flies. Ogbalu *et al.* (2005) reported that *Atherigona orientalis* is a major primary pest of bell pepper in Nigeria, stating that the fly oviposits on the fruit at the calyx, the grooves, and blossom end. He further indicates that the larvae can cause serious damage to both unripe and ripe fruit of most pepper cultivars in Nigeria. An information kit published by the government of Queensland, Australia lists *Atherigona orientalis* as

		a primary pest of tomato because the female fly will lay eggs in the cracks of the fruit and the developing larvae will ruin the fruit (Queensland Government 1998)." Eggs are approximately 0.9mm, last larval instar is 4-6mm long, and adult body length is 4mm and wing length is about 3mm (Hibbard & Overholt 2012). There is one interception record of it on ginger rhizomes. Other records of interceptions on produce at the New Zealand border include fresh beans, capsicum, eggplant, honeydew melon, rock melon, taro and copra meal. As it is frequently associated with damaged or rotting produce, it is unlikely to be associated with ginger rhizomes which meet the commodity definition..
Phoridae	*Megaselia albiclavata* Borgmeier, 1967	Phorids are scuttle flies/hump-backed flies. Adult phorids are very small, 0.4mm–6mm long and larvae average 3mm long. There is 1 record of an adult *M. albiclavata* interception on ginger (PaDIL, accessed Jan 2019). No host association with ginger was found so it is assumed this was incidental contamination and/or the ginger was rotten. The way of life of most phorid species is unknown. A few common, synanthropic species, especially *Megaselia scalaris*, *Dohrniphora cornuta*, *Megaselia rufipes*, and *Puliciphora borinquenensis*, live in almost any type of decaying organic material. The most commonly noticed species of phorid is *M. scalaris*, which is found in a number of filth-fly situations. The Phoridae is an extremely biologically diverse family: there are scavengers (some extraordinarily generalized, others highly specialized), herbivores, fungus-feeders, predators, parasitoids, and true parasites. Adults feed on honeydew, nectar, dead insects, carrion, host hemolymph; a few prey on insects. Many *Megaselia* species are found in fungi, some feeding on the fungus (including a few commercially important pests), others probably feeding on sciarid larvae (BugGuide 2017b). *M. albiclavata* is unlikely to be associated with ginger rhizomes which meet the commodity definition.
Platystomatidae	*Elassogaster* sp. nr *linearis*	This species has been found in ginger rhizomes in India (Sandhya 2015), though it is unclear if the rhizomes were healthy or diseased. Further

		information on this species was not found with regard to its ability to infest healthy ginger rhizomes. It is unlikely to be associated with ginger rhizomes which meet the commodity definition.
Sciaridae	*Pnyxia scabiei* (Hopkins, 1895)	The potato scab gnat is a fungus gnat about 1.1mm long This species is on the pest list from China. Guo *et al*. (2016) indicate it is a storage pest of ginger. Adults and larvae appear more strongly attracted to injured rhizomes than healthy rhizomes of American ginseng (Feng & Qin 2003) and it is potentially similar with ginger. No further information related to ginger rhizomes has been found. It is unlikely to be associated with ginger rhizomes which meet the commodity definition.
Syrphidae	*Eumerus albifrons* Walk. (Sathiamma, 1979) and *Eumerus figurans* (Walker, 1859) and *Eumerus pulcherrimus* Brunetti, 1915	Syrphids are hover flies/flower flies. The adults are between 5–12mm long and feed on nectar and pollen. Some larvae feed on decaying plant or animal matter in soil, ponds and streams. The larvae of many species predate aphids, thrips and other sap suckers (BugGuide 2018) Ravindran & Nirmal Babu (2004) record *Eumerus albifrons* as a pest of ginger. It seems likely it would be found on diseased rhizomes rather than those meeting the commodity definition. *Eumerus figurans* is called a 'ginger maggot'. It is attracted to injured and rotting bulbs, corms, and roots. The damage by this fly maggot is considered secondary, but it may aid in the spread of bacterial and fungal rot organisms (Sandhya 2015). The larvae of *Eumerus* spp. are clearly more saprophagous than phytophagous due to their morpho-functional adaptations and reported breeding sites (Ricarte *et al.* 2017). The presence of this species on ginger would indicate the rhizomes do not meet the commodity definition. Surveys conducted in Kerala indicated that 33.6% of diseased rhizomes contained fly larvae (*Mimegralla coeruleifrons* and *Eumerus pulcherrimus*), and none of the healthy rhizomes contained larvae (Koya 1988 in Ravindran & Nirmal Babu 2004). *Eumerus pulcherrimus* is unlikely to be associated with rhizomes that meet the commodity definition .

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7.5 Insects – Hemiptera (bugs)

Scale insects (which includes families Coccidae, Diaspididae and Monophlebidae) and **mealybugs** (family Pseudococcidae):

Some scales and mealybugs are only found on leaves and stems of host plants. Others such as *Aspidiella hartii* and *A. destructor* are intercepted on the pathway. These scale are found on the surface of ginger rhizomes, and other hosts such as yam and turmeric, during storage (Devasahayam & Koya 2016). Scale infestation is visible on the surface of surface of ginger rhizomes.

Other Hemiptera:

Some, such as whiteflies (family Aleyrodidae) were found to only affect leaves and stems (Plant Health Australia 2013, Devasahayam & Koya 2016, DAWR 2013). It was concluded that these would not be associated with ginger rhizomes.

Appendix 1 (Section 8) lists the potential bug (Hemiptera) hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following bugs were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Family	**Organism**	**Reason not requiring further assessment**
Aleyrodidae	*Aleurocanthus woglumi* Ashby, 1915	*Aleurocanthus woglumi* damages leaves and stems of *Z. officinale* (Plant Health Australia 2013). No information could be found describing *A. woglumi* damaging roots or rhizomes. It is unlikely to be associated with the pathway and was excluded from further assessment.
Aleyrodidae	*Aleurodicus dispersus* Russell, 1965	This whitefly is associated with the leaves of host plants, causing damage through feeding (EPPO, accessed March 2019). No information could be found describing *A. dispersus* damaging roots or rhizomes. It is unlikely to be associated with the pathway and was excluded from further assessment.
Aleyrodidae	*Aleurodicus dugesii* Cockerell 1896	*Aleurodicus dugesii* affects leaves of *Z. officinale* (Hutchings 2010). No information could be found describing *A. dugesii* damaging roots or rhizomes. It is unlikely to be associated with the pathway and was excluded from further assessment.
Aphididae	*Pentalonia nigronervosa* (Coquerel, 1859)	*Pentalonia nigronervosa* infests leaves of *Zingiber officinale* (Ravindran & Nirmal-Babu 2016). The aphid is also the vector of the banana bunchy top virus (Halbert & Baker 2015). No information could be found describing *P. nigronervosa* damaging roots or rhizomes. It is unlikely to be associated with the pathway and was excluded from further assessment.
Coccidae	*Ceroplastes rubens* Maskell, 1893	Adults and nymphs of *C. rubens* feed on stems, twigs and leaves of host plants and the infestations are clearly visible due to the wax covers of the scale (DEFRA 2014). It is unlikely that this scale would be associated with the ginger rhizomes. However, if they were to contaminate rhizomes post-harvest, it is likely they would be visible during inspection.
Diaspididae	*Aspidiella sacchari* (Cockerell 1893) and *Aspidiella hartii* (Cockerell, 1895)	DAWR (2013) found that a report by Devasahayam & Koya (2005, in DAWR 2013) of *A. sacchari* infesting ginger, i.e. 'rhizome infestation by *A. sacchari* is reported in both field and storage conditions', actually refers to *A. hartii*. The report prepared by the Australian ginger industry (Hutchings 2010) shows an infected rhizome. The infested rhizome is identified as 'rhizome scale' and is most likely *A. hartii*. Therefore, it is unlikely that *A. sacchari* would be associated with the pathway and was excluded from further assessment.

		The scale is known to be associated with *Z. officinale* rhizomes in-field and during storage (Devasahayam & Koya, 2005, in DAWR 2013). *Aspidiella hartii* has also been commonly intercepted on *Z. officinale* consignments at the New Zealand border (interception data). Other primary host species described for *A. hartii* are turmeric (*Curcuma longa*) and yams (*Dioscorea alata*) (ScaleNet(a), accessed 22 Mar 2019). On these pathways, as well as others, the scale is managed by visual inspection. As scale infestation is visible on the surface of surface of ginger rhizomes it has biological traits which indicate it is likely to be managed by minimum requirements.
Diaspididae	*Aspidiotus destructor* Signoret, 1869	The scale is found on the leaves and rhizomes of ginger (Devasahayam & Koya 2016). On other pathways scales are managed by minimum requirements including washing and visual inspection.
Diaspididae	*Aulacaspis tubercularis* (Newstead, 1906)	The scale feeds externally on young stems and fruit (Diaspididae of the World 2.0, accessed March 2019). No information could be found describing *A. tubercularis* damaging roots or rhizomes. Any contaminating scale insects would be visible during inspection.
Diaspididae	*Chrysomphalus dictyospermi* (Morgan, 1889)	From MPI (2014): '*C. dictyospermi* generally prefers leaves (usually the upper leaf surface; Salama 1970), but is occasionally found on fruit and branches (Watson 2005)'. Roots and rhizomes are not known to carry the pest in trade (CPC 2018a). Therefore, it is unlikely that *C. dictyospermum* would be associated with the pathway and was excluded from further assessment.
Diaspididae	*Hemiberlesia palmae* (Cockerell) Williams & Watson, 1988	This scale insect is likely to be found associated with leaves of *Z. officinale* (ScaleNet(b), accessed 22 Mar 2019). No information could be found describing *H. palmae* damaging roots or rhizomes. Any contaminating scales would be visible during inspection.
Diaspididae	*Pinnaspis strachani* (Cooley, 1899)	DAWR (2013) noted: '*Zingiber officinale* is a host of the scale (ScaleNet(c), accessed 22 Mar 2019) but as *P. strachani* attacks the leaves, stems and fruit of host plants (Tenbrink *et al.* 2007) it is unlikely to be associated with the ginger rhizome pathway'. Any contaminating mealybugs would be visible during inspection.

Diaspididae	*Pseudaonidia trilobitiformis* (Green, 1896)	*Pseudaonidia trilobitiformis* affects leaves and fruits (ScaleNet(d), accessed 22 Mar 2019) and is not reported to affect rhizomes. Therefore, it is unlikely that *P. trilobitiformis* is unlikely to be associated with the pathway and was excluded from further assessment.
Diaspididae	*Selenaspidus articulatus* (Morgan, 1889)	This scale insect attacks the leaves (especially the upper surfaces) and is sometimes found on the fruits/pods, growing points and stems of hosts and is not likely to be present on rhizomes (Watson 2011, DAWR 2013). Therefore, it is unlikely that the scale would be associated with ginger rhizomes. Any contaminating mealybugs would be visible during inspection.
Pseudococcidae	*Dysmicoccus brevipes* Cockerell, 1893	*Dysmicoccus brevipes* is a minor pest of ginger and feeds externally on the roots and leaves (DAWR 2013, CPC 2018b). Infestations are easily observed due to the mealybug producing copious amounts of white wax covering the adults (CPC 2018b).
Pseudococcidae	*Ferrisia virgata* (Cockerell, 1893)	This mealybug is reported to transmit *Cocoa swollen shoot virus, Citrus tristeza virus* and *Piper yellow mottle virus* (CPC 2019a). Plant parts likely to be affected by *F. viragta* are fruits, growing tips, leaves and stems (CPC 2019a). No information could be found describing the scale associated with rhizomes. Any contaminating mealybugs would be visible during inspection.
Pseudococcidae	*Formicoccus polysperes* Williams 2004	*Formicoccus polysperes* affects tropical plants that are not of economical or cultural significance to New Zealand (Williams 2004, Najitha *et al.* 2015). Infested ginger rhizomes were identified by the presence of obvious, white mealybug colonies are well as symbiotically associated ant colonies (Najitha *et al.* 2015). The mealybugs are described from the outside of the roots and rhizomes (Williams 2004, Najitha *et al.* 2015). Cleaning of the rhizomes is likely to remove the mealybug and any remaining would be visible during inspection.
Pseudococcidae	*Nipaecoccus nipae* (Maskell, 1893)	On host plants *N. nipae* affects fruit, growing tips, leaves, pods and stems (CPC 2018c). The mealybug feeds externally and infestations are easily visible due to distinct waxy females (CPC 2018c) and no information could be found describing *N. nipae* damaging roots or rhizomes. It is unlikely that the mealybug would be

		associated with the pathway and is excluded from further assessment.
Pseudococcidae	*Planococcus minor* (Maskell, 1897)	The mealybug is generally found on the stems of host plants and has been reported on leaves of ginger (Watson 2011, DAWR 2013). No information could be found describing *P. minor* damaging roots or rhizomes. Any contaminating mealybugs would be visible during inspection.
Pseudococcidae	*Pseudococcus jackbeardsleyi* Gimpel & Miller 1996	The mealybug is usually found on the stems and occasionally the leaves of host plants. It is unlikely that *P. jackbeardsleyi* would be present on rhizomes (Watson 2011, DAWR 2013). No information could be found describing *P. jackbeardsleyi* damaging roots or rhizomes. Any contaminating mealybugs would be visible during inspection. .
Miridae	*Cyrtorhinus lividipennis* Reuter, 1885	This mirid bug has been found associated with the commodity type 'Ginger' at the Plant Health & Environment Laboratory (PHEL) (PaDIL, accessed 11 Jun 2018). However, no information could be found describing *C. lividipennis* as a pest of *Zingiber* spp., or it being associated with the plant in the field. This species is used as a biocontrol agent against plant hopper pests on rice (Preetha *et al.* 2010, Han *et al.* 2017). The lack of information about *C. lividipennis* being associated with *Zingiber* spp. means that it is excluded from further assessment.
Monophlebidae	*Icerya seychellarum* (Westwood, 1855)	This scale insect is reported from leaves of the host plant, where it deposits honeydew (CPC 2018d). No information could be found describing *I. seychellarum* damaging roots or rhizomes. Any contaminating scale insects would be visible during inspection. It is unlikely to be associated with the pathway and was excluded from further assessment.
Tingidae	*Stephanitis typica* (Distant 1903)	*Stephanitis typica* affects the leaves of host plants and therefore is unlikely to be associated with the ginger rhizome pathway (CPC 2019b). No further assessment is required.

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7.6 Insects – Lepidoptera (butterlies, moths)

Most Lepidoptera recorded as being associated with ginger feed on leaves and/or other above-ground parts of plants and are thus unlikely to be associated with imported rhizomes. Several others are potential stored product pests on ginger rhizomes.

Appendix 1 (Section 8) lists the potential butterfly and moth hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following butterflies and moths were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Family	Organism	Reason for no further assessment
Crambidae	*Conogethes punctiferalis* (Queensland bollworm, maize moth, shoot borer, smaller maize	Highly polyphagous. On ginger larvae begin feeding on the green contents of the leaves and later bore into the shoots, feeding on the inner core. Larvae feeding in the centre of the stem cause the death of the “heart”, which is visible when the terminal shoots yellow. Usually, the larva is mature

	borer, yellow peach moth)	before it reaches the rhizome and leaves the stem to pupate: occasionally it arrives at the rhizome and damages it. Much of the species' distribution occurs in the subtropics; however it has also been recorded from northern Japan and China. All preceding information from Molet (2015). Feeding habits suggest it is highly unlikely to be associated with imported ginger rhizome, and it would be visually detectable if it was.
Crambidae	*Ostrinia furnacalis* (Asian corn borer)	Maize is the main host plant but it is also found on a range of other plants. Ginger listed as a 'main' host by CPC (2018a). The young instars only feed on the leaves; when it reaches the fourth instar it bores into the stem; in due course it pupates inside the tunnel which it has bored (Herbison-Evans & Crossley 2010). Feeding habits suggest it is highly unlikely to be associated with imported ginger rhizome, and it would be visually detectable if it was.
Crambidae	*Ostrinia nubilalis* (European maize borer)	Very wide host range, though favoured host is maize. Ginger is not listed as a host by CPC (2018b). It is likely that records of the pest in Asia represent misidentifications (CPC 2018b). CPC datasheet indicates the feeding strategy is similar to *O. furnicalis* (see entry for that species), so even if it is present in countries we will import ginger from, it is highly unlikely to be associated with imported ginger rhizome, and it would be visually detectable if it was.
Crambidae	*Piletocera xanthosoma* (pyralid moth)	This species may be associated with ginger, but it is an accidental contaminant rather than a pest of the crop; adults are strongly attracted to light at night, and females have been recorded as laying eggs on exposed produce in lighted dock sheds; quarantine concerns have been recorded through larvae hatching during transit of the produce; distribution - Fiji, Tonga (Henderson & Crosby 2014). Larvae feed on the outer rhizome tissue of ginger rhizomes, although may bore deeply into the rhizome under moist conditions, and produce large amounts of yellow frass (faeces) (Stout 1982, Hinckley 1964, in DAWR 2013). So may be associated with ginger root as a stored product pest; but has biological traits which indicate it is likely to be managed by minimum requirements (rhizome damage and insects and/or frass should be visually detectable).
Hesperiidae	*Udaspes folus* (grass demon)	Distribution – India; host plants – turmeric, ginger (CPC 2018c). 'Moderately common' in Singapore;

		host plants mainly in Zingiberaceae and Costaceae; larvae feed on leaves (Tan 2013). Tan (2013) references 'Butterflies of Thailand' and 'Butterflies of the Malay peninsula'; these books could not be accessed, but the citations suggest *U. folus* is present in at least one country from which ginger may be imported. Feeding habits suggest it is highly unlikely to be associated with imported ginger rhizome, and it would be visually detectable if it was, and unlikely to have a significant impact in New Zealand.
Noctuidae	*Spodoptera exigua* (lesser armyworm, beet armyworm)	Recorded from Europe, Asia, Africa, Australia and North America, and is most common in warm climates; a subtropical and tropical species; a polyphagous pest which attacks most kinds of field crops; larvae are leaf feeders (CPC 2018d). Ginger not listed as a host by CPC (2018d). Feeding habits suggest it is highly unlikely to be associated with imported ginger rhizome, and it would be visually detectable if it was.
Noctuidae	*Spodoptera frugiperda* (fall armyworm)	Feeds in large numbers on leaves and stems of more than 80 plant species, causing major damage to economically important cultivated grasses such as maize, rice, sorghum, sugarcane but also other vegetable crops and cotton; native to tropical and subtropical regions of the Americas, now widespread in Africa (neither Asia nor Oceania listed in Distribution Table); larvae feed on leaves, older larvae may cut stems (CPC 2019). Recently *S. frugiperda* has invaded Asia, and has been reported from India, China, Myanmar, Thailand, Bangladesh and Sri Lanka (MPI 2019). Feeding habits suggest it is highly unlikely to be associated with imported ginger rhizome, and it would be visually detectable if it was.
Pyralidae	*Maruca vitrata* (syn. *M. testulalis*) (bean pod borer)	Found throughout the tropics; it is often exported with legumes to other areas of the world, but is unable to survive in temperate climates; nearly all known hosts are in the family Fabaceae; young larvae may feed on any part of the flowers or foliage, but later-instar larvae are more common in the pods (CPC 2018e). There are five interception records at the NZ border of *M. vitrata* on ginger rhizome up until January 2019 (the most recent being June 2000), of a total of 1,529 interceptions of this species, most on Fabaceae (LIMS). So, ginger appears to be an uncommon host, the pest is unlikely to be associated in the field with roots/rhizomes of host plants, is thus unlikely to be

		associated with imported ginger rhizome. If it is associated with imported ginger rhizome, the larvae or damage are likely to be visually detectable. *Maruca vitrata* may not be able to establish over much of New Zealand.
Tineidae	*Opogona regressa*	Distribution: Fiji (Catalogue of life 2011a – accessed 29 Mar 2019). Also recorded from Rarotonga in the Cook Islands (Cook Islands Natural Heritage Trust 2005). Recorded on ginger in Fiji (HOSTS – accessed 29 Mar 2019). Most tineid larvae feed on plant or animal detritus, lichen or fungi, rather than living plants (Catalogue of life 2011b – accessed 29 Mar 2019). There is potential for *O. regressa* to be on ginger rhizome pathway from Fiji (Biosecurity Australia 2007), as larvae of several *Opogona* species attack stored tubers and occasionally feed on living plant material adjacent to decaying material (Robinson & Tuck 1997, in Biosecurity Australia 2007). So there is potential for *O. regressa* to be on decaying ginger from Fiji as a stored product pest but it has biological traits which indicate it is likely to be managed by minimum requirements. May not be able to establish outside over much of NZ.
Tineidae	*Setomorpha rutella*	Found across the tropics from America, through Africa and Asia to the Pacific islands and Australia (Qld, NSW); larvae feed on dried vegetable material including grain, nuts, and seeds (Herbison-Evans & Crossley 2015). So, potential to be on ginger rhizome import pathway as stored product pest but it has biological traits which indicate it is likely to be managed by minimum requirements (rhizome damage and/or insects should be visually detectable). May not be able to establish outside over much of New Zealand.

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7.7 Insects – Ants (Hymenoptera)

As a rhizome growing just under, and at the soil surface, ginger has a high likelihood of being in contact with ants and ant colonies. Good cleaning and visual inspection should get rid of most ants. However, a residual possibility of hitchhikers remains given the complex structure and numerous interstices provided in packed crates of ginger. There have been approximately 80 interceptions of ants on ginger at the New Zealand border (LIMS database 1987-2017). The species/genera intercepted are listed in the potential hazard table in Appendix 1 (Section 8)..

All ant species have biological traits which mean that they are likely to be managed by the minimum requirements:

- ants present on rhizomes at harvest should be removed by post-harvest processing;
- ants should be easily visually detected on the commodity;
- most interceptions are of worker ants that could not establish, and
- the National Invasive Ants Surveillance programme at high risk sites in New Zealand reduces the risk of establishment.

Appendix 1 (Section 8) lists the potential ant hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found (in most cases because of interceptions on ginger). The following ants (in the table below), which are regulated (or in the case of *Paratrechina* sp., have a regulated species in the genus) in BORIC, were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Given that ants are associated with ginger rhizome imports as hitchhikers, and do not have a biological association with the commodity, other ant species not identified in Appendix 1 but present in countries from which ginger is/will be imported are also potential hazards; however, they have biological traits which indicate they are likely to also be managed by minimum requirements for the bullet-pointed reasons above.

Family	Organism	Reason for no further assessment
Formicidae	*Camponotus chloroticus*	Regulated. One interception on ginger at the New Zealand border, from Fiji. Not biologically

		associated with ginger rhizomes, but may be present as a hitchhiker. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Formicidae	*Monomorium minutum*	Regulated. One interception on ginger at the New Zealand border, from Fiji. Some *Monomorium* species are considered pests. Not biologically associated with ginger rhizomes, but may be present as a hitchhiker. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Formicidae	*Nylanderia vaga* / *Paratrechina vaga* *	*Nylanderia vaga* is regulated and BRAD considers *Paratrechina vaga* a synonym. However, the taxonomy of these two "species" is confused.* Harris & Berry (~2004) note that *P. vaga* is a potential pest in urban areas and a potential minor agricultural pest. *Paratrechina vaga* has been recorded as intercepted on ginger at the New Zealand border seven times, with Fiji the most common country of origin. Not biologically associated with ginger rhizomes, but may be present as a hitchhiker. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Formicidae	*Paratrechina* sp.	*Paratrechina* sp. have been recorded as intercepted on ginger at the New Zealand border 33 times, with Fiji the most common country of origin. *Paratrechina longicornis* is a species of concern (listed in MPI (2011) - a longlist of high priority risk organisms) that is present in countries from which ginger is/will be imported. Not biologically associated with ginger rhizomes, but may be present as a hitchhiker. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Formicidae	*Pheidole fervens*	Regulated. Listed in MPI (2011) - a longlist of high priority risk organisms. *Pheidole* sp. have been recorded as intercepted on ginger at the New Zealand border 42 times, with Fiji the most common country of origin. Not biologically associated with ginger rhizomes, but may be present as a hitchhiker. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Formicidae	*Tapinoma melanocephalum*	Regulated. Invasive (USA). Listed in MPI (2011) - a longlist of high priority risk organisms. A household pest that can form nests inside dwellings and will compromise food sources (Doherty 2013). Not biologically associated with ginger rhizomes,

		but may be present as a hitchhiker. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Formicidae	*Technomyrmex albipes*	Regulated. Three interceptions on ginger at the New Zealand border, once each from Fiji, Australia and Singapore. Invasive, nests in man-made structures. Not biologically associated with ginger rhizomes, but may be present as a hitchhiker. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Formicidae	*Tetramorium simillimum*	Regulated. Intercepted on ginger at the New Zealand border 4 times, with Fiji the most common country of origin. Not biologically associated with ginger rhizomes, but may be present as a hitchhiker. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Formicidae	*Tetramorium tonganum*	Regulated. Not biologically associated with ginger rhizomes, but may be present as a hitchhiker. This mite has biological traits which indicate it is likely to be managed by minimum requirements.

* "Species identifications within *Nylanderia* are often suspect given the taxonomic uncertainties with the genus. Additionally, the identities of some reportedly invasive species, such as *Nylanderia bourbonica* and *Paratrechina vaga*, have never been clarified" (LaPolla *et al.* 2011).

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7.8 Insects – Psocoptera (bark lice, book lice)

As a rhizome growing just under, and at the soil surface, ginger has the potential of being in contact with psocids present in leaf litter. Cleaning and visual inspection should remove most surface invertebrates on the commodity at harvest. However, the risk of post-harvest association remains given that some psocids are stored product pests. Psocid storage product pests are described as secondary pests and mould feeders (Rees 2004); as such they may be more likely to be associated with damaged rhizomes than those of export quality.

Psocids have biological traits which indicate they are likely to be managed by minimum requirements, because:

- post-harvest processing should remove psocids from the rhizome surface;
- as storage product pests they may be more likely to be associated with damaged rhizomes or rhizomes exhibiting fungal rot;
- many species would be detected visually on rhizomes (they are mostly less than 2 mm, though up to 10 mm);
- while individuals of some species remaining on the rhizome, or becoming associated with the rhizome post-harvest, may not be easily detected because of their small size and cryptic colouring, psocids typically have soft bodies, slender legs and wings, making them fragile and easily damaged in moving cargo, reducing the likelihood of viable arrivals.

There have been 23 interceptions of Psocoptera on ginger at the New Zealand border since 1987 (LIMS database). Of these only three were identified, and only one (*Psoquilla marginepunctata*, from Fiji) to species level. *Psoquilla marginepunctata* has not been recorded from New Zealand.

Appendix 1 (Section 8) lists the potential psocid hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following psocids were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Family	Organism	Reason for no further assessment
Psoquillidae	*Psoquilla marginepunctata*	*Psoquilla marginepunctata*, can be found in association with grains and stored foods (García Aldrete & Gutiérrez Díaz 1995), degrading their quality and market value. It is a circumtropical

		species introduced into some temperate lands. In the tropics it occurs primarily outdoors; in temperate countries it occurs in houses, warehouses and greenhouses (Aldini 2000). While this is a small psocid (1 mm) its body and wings are black with white distinctive markings (Psocoptera (Book Lice), retrieved 30 May 2019), so that it is likely to be easily visible on clean ginger rhizomes. It feeds on fungus and organic debris (Psocoptera (Book Lice), retrieved 30 May 2019) so may be more likely to be associated with ginger rhizomes exhibiting fungal rot. This mite has biological traits which indicate it is likely to be managed by minimum requirements.

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7.9 Acari (mites)

Although a number of mite species have been intercepted on ginger the majority of these do not appear to have a natural host association with ginger or ginger rhizomes, but are contaminants and the result of non-compliance (*e.g.* a nematophagous mite of root knot nematodes, common fungal feeding mites). The mites are very small but are detectable by size and/or colour.

Appendix 1 (Section 8) lists the potential mite hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found. The following mites were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Family	Organism	Reason for no further assessment
Acaridae	*Cosmoglyphus oudemansi* Zachvatkin, 1937	This mite has a broad world distribution, although there is very little useful information on it. Mites are mostly very small, being less than a millimetre long. General searches indicate it is associated with stored grain products (*e.g.* Hubert *et al*. 2006) and bird nests (*e.g.* Ardeshir 2010). Although published reports were not found in association with ginger rhizomes, it has been intercepted in ginger consignments. It is assumed that this is contamination from either soil, dust or storage rather than a host association with ginger. The Acaridae are generally of moderate length, pale whitish to brownish in colour, and some species are weakly pigmented (Vacante 2016). These mites are likely to be visible by movement and in some cases their colour. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Acaridae	*Rhizoglyphus setosus* Manson, 1972 and *Rhizoglyphus singularis* Manson, 1972	The genus *Rhizoglyphus* is commonly associated with bulbs and corms of different plants and is found in various substrates. About 13 species are recognised as crop pests or closely associated with cultivated plants (Vacante 2016). *Rhizoglyphus setosus* has a worldwide distribution through the subtropics and tropics. It has been intercepted from a consignment of ginger. The usual literature searches have not shown a host association with ginger rhizomes, although it has been reported from the decaying rhizomes of the ornamental *Curcuma roscoeana* (family Zingiberaceae) (Akiyama *et al*. 1997, in Vacante 2016). In Taiwan this mite has been reported from a number of ornamental species that are grown from bulbs but also from onion (to which it is reported to be injurious (Chen *et al*. 2002b in Vacante 2016)), garlic, spring onion, carrot, sweet potato and maize (APASD accessed 2018). *Rhizoglyphus setosus* can develop strong pesticide resistance and be very difficult to control (APASD, accessed 2018). This mite has been reported on mealybugs on pineapples (Manson 1972). According to Vacante (2016), in addition to direct damage to bulbs the presence of bulb mites has been associated with pathogenic fungi and bacterial development.

		The *R. setosus* female idiosoma (main body) is 465-686 µm long. These mites are likely to be visible by movement and in some cases their colour. *Rhizoglyphus singularis* has been intercepted at the border on ginger, also yams and taro (Fan & Zhang 2004). The genus is known to be associated with bulbs and corms. Reports not found of it as a pest of ginger rhizomes but it was reported from *Hedychium* spp. (family Zingiberaceae) which is a flowering ornamental or invasive species. These mites should be visible by movement and in some cases their colour. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Acaridae	*Schwiebea similis* (Manson, 1972) and *Schwiebea zingiberi* Manson, 1972	*Schwiebea similis* has been intercepted on taro tubers at the border. Reports not found of host association with ginger, only in an experimental context which is described in the following sentences. "In China it is considered a new pest on American ginseng, *Panax quinquefolium* L. The root mite *Schwiebea similis* Manson bores into and feeds on tissues inside roots of the plant, causing remarkable losses" (Zhao & Chen 2016). Guo *et al.* (2016) experimentally fed it on 9 crops; ginger was 2nd to last in ranking food preference: "the rank of mean value on food crops from high to low was garlic (*Allium sativum*, clove), potato (*Solanum tuberosum*, tuber), Chinese yam (*Dioscorea opposita*, tuber), American ginseng (*Panax quinquefolium*, taproot), turnip (*Raphanus sativus*, taproot), carrot (*Daucus carota*, taproot), spring onion (*Allium fistulosum*, white leaf-sheath), ginger (*Zingiber officinale*, rhizome), and wheat (*Triticum aestivum*, fibrous root)". There is very little information available on this mite, not enough to assess further. Any damage to the rhizome may indicate infestation. *Schwiebea zingiberi* has been intercepted at the border on ginger, tarua, yam, turmeric and taro. Information was not available on this mite. Its name suggests it may feed upon plants in either the genus *Zingiber* or the family Zingiberaceae. It is present in Australia, Fiji and Thailand and on the pest lists for ginger from those countries. The length of the idiosoma for number of female *Schwiebea* species is between 300-400 µm. This

		mite has biological traits which indicate it is likely to be managed by minimum requirements.
Acaridae	*Tyrophagus javensis* (Oudemans, 1916) and *Tyrophagus perniciosus* Zakhvatkin, 1941	*Tyrophagus javensis* has been intercepted on ginger at the border, and other fresh produce such as banana, pineapple, rockmelons, yams, watermelon. The genus is known to be economically important as stored food and product pests. Some species are injurious to plants. Reports not found of a host association with ginger rhizomes. The idiosoma in members of the genus *Tyrophagus* is between 300-600 µm long and whitish to semi-transparent in colour. Given the genus is often detected at the border this species should be visible by movement and possibly colour. *Tyrophagus perniciosus* has been intercepted on ginger, watermelon, rockmelon and lemon at the border. It is reported to feed on melon, cucumber and pumpkin plants and is frequently associated with stored products and houses (Zhang 2003). Vacante (2016) considers it one of the more injurious species of *Tyrophagus*. Although intercepted on ginger Reports not found of a host association with ginger rhizomes. It is a relatively large mite (females 550-700 µm long) and would be visible by movement and potentially its colour. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Ascidae	*Lasioseius subterraneus* Chant, 1963	This species is a predatory mite and is nematophagous upon root-knot nematodes. It is reported to consume about 15 nematodes daily and other members of the genus have also been reported as aggressive nematophages (Walter *et al*. 1993). It has been intercepted once in a consignment of ginger rhizomes entering New Zealand. As it doesn't have a host association with ginger rhizomes it is likely to have been an incidental contaminant. It is likely to be visible by movement. This mite has biological traits which indicate it is likely to be managed by minimum requirements.
Tetranychidae	*Tetranychus kanzawai* Kishida, 1927 And *Tetranychus okawanus* Ehara, 1995	Migeon & Dorkeld (accessed 6 Mar 2019) list *Zingiber officinale* as a host for *T. kanzawai*. However, tetranychids are almost always associated with leaves, shoots and sometimes with fruit (Vacante, 2016). Reports not found of this mite associated with the rhizome. MPI interception records do not show any detections of tetranychid interceptions on ginger. No further assessment is required, however, should new information become

		available then this mite should be reassessed. **Note: This mite is on the MPI organism ranking list and has measures above minimum requirements under some IHSs for host plant parts it can be transported on.** Migeon & Dorkeld (accessed 6 Mar 2019) lists *Zingiber mioga* and *Curcuma longa* as hosts for *T. okawanus*. As tetranychids are almost always associated with leaves, and sometimes with fruit (Vacante, 2016) it is unlikely that it would be associated with rhizomes. Reports not found of this mite associated with the rhizome of *Z. officinale* or *Z. zerumbet*. MPI interception records do not show any detections of tetranychid interceptions on ginger. No further assessment is required.
Tenuipalpidae	*Raoiella indica* Hirst, (1924) Red palm mite	This is an invasive mite well-known for its damage to coconut palms and date palms (Navia *et al*. 2011) Since arriving in the Americas it has been reported from bananas, and tropical ornamental plants in the Heliconiaceae, Strelitziaceae and Zingiberaceae (Navia *et al*. 2011). It is reported from tropical latitudes and is known to breed on monocots. It is primarily associated with leaves and would not be expected to be associated with rhizomes. Although CPC (2018) give "Zingiber (ginger)" as a "wild host", it is unreferenced and Reports not found of it on ginger rhizomes. The adult female is between 267-300 µm long and is red (as are all lifestages including eggs) (CPC 2018). It should be visible by colour and movement. This mite has biological traits which indicate it is likely to be managed by minimum requirements.

7.9.1 References

APASD. Asian Pacific Alien Species Database. http://www.naro.affrc.go.jp/archive/niaes/techdoc/apasd/

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7.10 Molluscs (snails, slugs)

As a rhizome growing just under, and at the soil surface, ginger has a high likelihood of being in contact with terrestrial molluscs (snails and slugs) crawling at the surface. Good cleaning and visual inspection should get rid of these molluscs (including their eggs) on the commodity at harvest. However, the risk of hitchhikers remains given the possibility of post-processing association and the complex structure and numerous interstices provided in packed crates of ginger. There have been 30 interceptions of molluscs on ginger at the New Zealand border over the last 30 or so years (LIMS database 1987-2017, QuanCargo), although more than half of these were not identified to genus level.

All snail and slug species have biological traits which indicate they are likely to be managed by minimum requirements, because:

- those present on rhizomes at harvest should be removed by post-harvest processing, and
- they can be visually detected on the commodity;

Appendix 1 (Section 8) lists the potential snail and slug hazards, i.e. those for which some evidence of association to ginger (*Zingiber* spp.) was found (in most cases because of interceptions on ginger). The following snails and slugs (in the table below), which are regulated (or in the case of *Arion* sp., have a regulated species in the genus) in BORIC, were considered as part of the hazard identification process but do not meet the criteria for further assessment for measures additional to minimum requirements. A more detailed risk assessment for species not meeting these criteria was beyond the scope of this project.

Given that snails and slugs are likely to be associated with ginger rhizome imports as hitchhikers, and do not necessarily have a biological association with the commodity, other snail species not identified in Appendix 1 may also be potential hazards; however, they have biological traits which indicate they are likely to also be managed by minimum requirements for the bullet-pointed reasons above.

Family	**Organism**	**Reason for no further assessment**
Arionidae	*Arion* sp.	This genus of slugs contains a number of pest species. Three are already present in New Zealand but new ones could be damaging, and one, the European black slug *A. ater*, is Regulated and present in at least one country (Australia) that can export ginger to New Zealand. One interception of *Arion* sp. on ginger (from Fiji) at the New Zealand border. May not be biologically associated with ginger rhizomes, but may be present as a hitchhiker. Biological traits indicate that it is likely to be managed by minimum requirements (post-harvest processing, inspection).
Achatinidae	*Achatina fulica*	*Achatina fulica*, the giant African snail, is a Regulated and Notifiable organism. Considered one of the world's worst invasive pests (Brodie & Barker 2012) and a threat to local flora. IUCN's Global Invasive Species Database states "There is a huge risk of the giant African snail (*Achatina fulica*) being spread and introduced into new locations via trade routes" (ISSG, accessed Dec 2018). If it established in New Zealand it is estimated (by expert elicitation of MPI's New Zealand Organism Ranking System) it would have an economic impact of $12.4 M over 10 years. No interceptions on ginger but numerous interceptions on other products. This is a very large snail (up to 200 mm) and all stages should be easily visually detected on ginger. Biological traits indicate that it

		is likely to be managed by minimum requirements (post-harvest processing, inspection).
Veronicellidae	*Veronicella leydigi*	The black slug, *Veronicella leydigi*, is a Regulated organism. It is a pest on coffee, tobacco, sweet potatoes, sugarcane, vegetables, in the West Indies, India and South America (Molet 2014). It is listed as a species of concern in Australia and Fiji. It has been intercepted once on ginger (from Fiji) at the New Zealand border. It has been intercepted on cars in USA (Molet 2014), emphasising its status as a hitchhiker. May not be biologically associated with ginger rhizomes, but may be present as a hitchhiker. Biological traits indicate that it is likely to be managed by minimum requirements (post-harvest processing, inspection).

7.10.1 References

BORIC. Biosecurity Organisms Register for Imported Commodities (MPI database). https://www.mpi.govt.nz/news-and-resources/resources/registers-and-lists/biosecurity-organisms-register-for-imported-commodities/

Brodie, G; Barker, G M (2012) *Achatina* (*Lissachatina*) *fulica* (Bowdich, 1822). Family Achatinidae. Pages 1-2 *in* U. I. L. S. o. t. F. I. F. S. Series, editor.

ISSG. Global Invasive Species Database. http://www.iucngisd.org/gisd/search.php.

LIMS. Laboratory Information Management System. MPI internal database of organisms detected at the New Zealand border and identified by the MPI Plant Health and Enviroment Laboratory.

Molet, T (2014) CPHST Pest datasheet for *Veronicella* spp.*in* USDA-APHIS-PPQ-CPHST, editor.

QuanCargo. MPI internal database of imported commodity consignments.

8 Appendix 1 Hazard identification table

The following table contains the list of potential hazards found to be associated with *Zingiber* spp. from the following sources: CABI Crop Protection Compendium (2018/9) (including CABI horizon scan, list of all potential risks for ginger (all *Zingiber*) imports to NZ, CABI horizon scan extract_20180319), CAB Abstracts, Google scholar, Google, existing pest lists from ginger IHSs, interception data (LIMS, QuanCargo), Farr & Rossman (2017/2018) (for fungi and oomycetes), García Morales (2016) (for scale insects), Migeon & Dorkeld (2018) (for mites), Nemaplex (for nematodes), MPI Emerging Risks System database, general literature searches (see Section 3.3 for references).

The table shows information about the presence in New Zealand of the identified organisms and identifies the sources linking the organisms to ginger (*Zingiber* spp.). See the key following the table for more detail about the sources used ('Association with Zingiber' column) and links to the sources.

Key to colour-coding of cells:

(grey)	Species/sub-specific taxon recorded as present in New Zealand
(white)	Species/taxon **not** recorded as present in New Zealand
(peach)	Only identified to genus level; genus **not** recorded as present in New Zealand
(green)	Species/sub-specific taxon presence in New Zealand uncertain

	Present in NZ?	Association with *Zingiber*	Further assessment)?
Bacteria			
Bacillus pumilus	Yes	CABI horizon scan (9), 72	***Pantoea ananatis* requires further assessment (see Targeted PRA in Section 6.1) as it may require measures beyond the minimum requirements. The pathogen may be associated with ginger rhizomes asymptomatically and has the potential to establish and cause significant economic damage in New Zealand.** No other bacteria were considered to meet the criteria for measures beyond minimum requirements because: • exposure (and therefore establishment) of phytoplasmas from fresh produce is unlikely; • other bacteria are unlikely to establish and/or have significant impacts in NZ for climatic reasons or because they are specific to ginger; • in addition they may present detectable symptoms on rhizomes. **See Section 6.2 for a more detailed bacteria Hazard ID assessment**
'*Candidatus* Phytoplasma asteris'	No	CABI horizon scan (9)	
Dickeya sp.	Yes (genus)	Australian IRA	
Enterobacter cloacae	Yes	CABI horizon scan (9)	
Enterobacter cloacae subsp. *cloacae*	? (species is present)	71	
Erwinia carotovora	Yes	2006 IHS	
Erwinia carotovora subsp. *carotovora*	Yes	2006 IHS, Australian IRA	
Erwinia chrysanthemi (*Dickeya* in NZFUNGI2)	Yes, some strains	2006 IHS	
Erwinia sp.	Yes (genus)	Pacific Pest List	
Pantoea ananatis	No	CABI horizon scan (9), 69	
Pectobacterium carotovorum subsp. *carotovorum*	Yes	70	
Pseudomonas aeruginosa	Yes	2006 IHS	
Pseudomonas fluorescens	Yes	2006 IHS, LIMS, 71	
Pseudomonas marginalis	Yes	CABI horizon scan (9)	
Ralstonia solanacearum	Yes, some strains	1998 IHS, 2006 IHS, Australian IRA, China pest list, 67, 68	
Xanthomonas zingiberi	No	2006 IHS	
Xanthomonas campestris pv. *zingibericola*	No	93	
Collembola (springtails)			
Degamaea sp.	No (genus)	LIMS	Most springtails are soil/leaf litter dwellers and may be associated with soil attached to ginger rhizomes. They are omnivorous and commonly consume fungal hyphae, and could potentially be associated with rotting rhizomes. Springtails are unlikely to be associated with ginger rhizomse meeting the commodity definition.
Entomobrya sp.	Yes (genus)	LIMS	
Hypogastrura sp.	Yes (genus)	LIMS	
Lepidocyrtus sp.	No (genus)	LIMS	
Onychiurus sp.	Yes (genus)	LIMS	
Proisotoma sp.	Yes (genus)	LIMS	
Seira sp.	Yes (genus)	LIMS	
Seira sp.	Yes (genus)	LIMS	
Xenylla sp.	Yes (genus)	LIMS	
Fungi			
Acremonium kiliense	Yes	LIMS, QuanCargo	

	Present in NZ?	Association with *Zingiber*	Further assessment)?
Acremonium murorum	Yes	79	No fungi were considered to require measures beyond minimum requirements because they are either not associated with rhizomes, or cause visible rot of ginger rhizomes so therefore are unlikely to be associated with ginger rhizomes meeting the commodity definition. **See Section 7.1 for a more detailed fungus Hazard ID assessment**
Acrostalagmus luteoalbus	Yes	79	
Alternaria alternata	Yes	2006 IHS, 76, 77	
Armillaria mellea	No	1998 IHS, 2006 IHS, Australian IRA	
Aspergillus candidus	Yes	2006 IHS	
Aspergillus luchuensis	Yes	2006 IHS	
Aspergillus niger	Yes	2006 IHS	
Aspergillus parvisclerotigenus	No	78	
Aspergillus terreus	Yes	QuanCargo	
Athelia rolfsii	Yes	1998 IHS, 2006 IHS, Pacific Pest List	
Bionectria ochroleuca	Yes	2006 IHS	
Boeremia exigua var. *exigua*	Yes	CABI horizon scan (9), Australian IRA	
Botryosphaeria rhodina (anamorph *Lasiodiplodia theobromae*)	Yes	2006 IHS	
Ceratobasidium sp.	Yes (genus)	Pacific Pest List	
Cladosporium cladosporioides	Yes	2006 IHS, LIMS	
Cladosporium tenuissimum	Yes	2006 IHS, CABI horizon scan (9)	
Clonostachys sp.	Yes (genus)	LIMS	
Cochliobolus geniculatus	Yes	2006 IHS, Australian IRA	
Cochliobolus lunatus	Yes	1998 IHS	
Colletotrichum gloeosporioides	Yes, some strains	1998 IHS, 2006 IHS, Australian IRA, Pacific Pest List	
Colletotrichum truncatum	Yes	Australian IRA	
Cylindrocladium sp.	No (genus)	Pacific Pest List	
Dipodascus geotrichum	Yes	1998 IHS	
Emericella nidulans	Yes	CABI horizon scan (9)	
Epicoccum purpurascens	Yes	2006 IHS, LIMS	
Fusarium oxysporum	Yes	1998 IHS, 2006 IHS, Australian IRA, Pacific Pest List, LIMS, 79, 80	
Fusarium oxysporum f.sp. *zingiberi*	No	Australian IRA, CABI horizon scan (9)	
Fusarium sp.	Yes (genus)	LIMS, 79	
Galactomyces geotrichum	Yes	2006 IHS	
Geotrichum candidum (citrus race)	Yes	CABI horizon scan (9)	
Gibberella baccata	Yes	2006 IHS, Australian IRA, Pacific Pest List	
Gibberella fujikuroi	Uncertain	1998 IHS, 2006 IHS	
Gibberella intricans	Yes	1998 IHS, 2006 IHS	
Gibberella subglutinans	Yes	2006 IHS, Australian IRA	
Gibberella zeae	No	81	
Glomus sp.	Yes (genus)	Pacific Pest List	
Haematonectria haematococca	Yes	2006 IHS, Australian IRA, Pacific Pest List, 82	
Khuskia oryzae	Yes	CABI horizon scan (9), 84	
Lasiodiplodia theobromae	Yes	1998 IHS, 74, 75	
Macrophomina phaseolina	Yes	2006 IHS, Australian IRA	

	Present in NZ?	Association with *Zingiber*	Further assessment)?
Memnoniella echinata	Yes	Australian IRA	
Memnoniella echinata	Yes	2006 IHS	
Mucor hiemalis	Yes	2006 IHS	
Mucor racemosus	No	2006 IHS, CABI horizon scan (9)	
Myrothecium verrucaria	Yes	CABI horizon scan (9), 83	
Phaeoisaria clematidis	Yes	LIMS, QuanCargo	
Phyllosticta zingiberi	No	CABI horizon scan (9), China Pest List	
Proxipyricularia zingiberis	No	1998 IHS, 2006 IHS, CABI horizon scan (9)	
Rhizoctonia sp.	Yes (genus)	Pacific Pest List	
Rhizopus stolonifer	Yes	CABI horizon scan (9)	
Rhizostilbella hibisci	Yes	Australian IRA	
Rosellinia bunodes	No	2006 IHS, CABI horizon scan (9)	
Sclerotium rolfsii	Yes	Australian IRA, CABI horizon scan (9)	
Scolecobasidium humicola	No	2006 IHS	
Taphrina maculans	No	CABI horizon scan (9)	
Thanatephorus cucumeris	Yes	1998 IHS, 2006 IHS, Australian IRA	
Trichoderma viride	Yes	LIMS	
Trichurus spiralis	Yes	2006 IHS	
Ulocladium chartarum	Yes	LIMS	
Verticillium albo-atrum	Yes (as V. albo-atrum)*	2006 IHS, Australian IRA	
Insects – Blattodea (cockroaches)			
Blattella germanica	No	LIMS, QuanCargo	Cockroaches are only likely to be present on ginger rhizomes as hitchhikers, or possibly stored product pests. They are are unlikely to be associated with ginger rhizomes meeting the commodity definition..
Megamareta phaneropyga	No	LIMS	
Megamareta sp.	No	LIMS	
Neolemnopteryz fulva	Yes	LIMS, QuanCargo	
Periplaneta sp.	Yes (genus)	LIMS	
Insects – Coleoptera (beetles)			
Abacetus sp.	No (genus)	EPPO	No Coleoptera were considered to meet the criteria for measures beyond minimum requirements for one or more of the following reasons: • they are unlikely to be associated with ginger rhizomes; • they are unlikely to be associated with ginger rhizomes meeting the commodity definition.even if they are associated with ginger rhizomes; • for climatic reasons they are unlikely to establish in NZ, or form damaging populations if they do; • they are unlikely to have a significant impact if they established in NZ; • they are not present in countries from which ginger will be imported. **See Section 7.4 for a more detailed Coleoptera Hazard ID assessment**
Acrotrichis flavipennis	No	QuanCargo	
Adoretus sinicus	No	CABI horizon scan (9)	
Adoretus versutus	No	1998 IHS, Australian IRA, CABI horizon scan (9)	
Alphitobius laevigatus	Yes	EPPO	
Anthicus sp.	No (genus)	LIMS	
Araecerus fasciculatus	Yes	2006 IHS	
Atheta sp.	Yes (genus)	LIMS	
Austrolophrum cribriceps	Yes	LIMS	
Austrolophrum sp.	Yes (genus)	LIMS	
Brahmina coriacea	No	CABI horizon scan (9)	
Calodera sp.	Yes (genus)	LIMS	
Carpelimus sp.	No (genus)	LIMS	
Carpophilus sp.	Yes (genus)	CABI horizon scan (9)	
Carpophilus mutilatus	No	21, LIMS	
Caulophilus oryzae	No	CABI horizon scan (9)	
Chaeridiona mayuri	No	CABI horizon scan (9), 22	
Corticaria sp.	No (genus)	LIMS	
Cryptamorpha desjardinsi	Yes	QuanCargo, LIMS	
Cryptolestes ferrugineus	Yes	QuanCargo, LIMS	
Cryptolestes pusilloides	Yes	LIMS	

	Present in NZ?	Association with *Zingiber*	Further assessment)?
Dacne sp.	No (genus)	EPPO	
Dermestes maculatus	Yes	LIMS	
Drasterius sp.	No (genus)	EPPO	
Elytroteinus subtruncatus	No	1998 IHS, Australian IRA, QuanCargo, LIMS	
Haptoncus ocularis	No	LIMS, QuanCargo, 23	
Lasioderma serricorne	Yes	2006 IHS, Australian IRA, LIMS, CABI horizon scan (9)	
Litargus sp.	No (genus)	LIMS	
Phloeonomus sp.	No (genus)	LIMS	
Phyllophaga sp.	No (genus)	Ginger Pest List 20180324	
Protaetia sp.	No (genus)	LIMS	
Rhyzopertha dominica	Yes	CABI horizon scan (9)	
Rhyzopertha dominica	Yes	24	
Scaphisoma distans	No	QuanCargo	
Sericoderus sp.	Yes (genus)	LIMS	
Stegobium paniceum	Yes	CABI horizon scan (9), 25	
Tachinus sp.	No (genus)	LIMS	
Tribolium castaneum	Yes	2006 IHS, CABI horizon scan (9), 26	
Typhaea stercorea	Yes	QuanCargo, LIMS	
Insects – Dermaptera (earwigs)			
Chelisoches morio	Yes	LIMS, QuanCargo	Earwigs are only likely to be present on ginger rhizomes as hitchhikers. They are unlikely to be associated with ginger rhizomes meeting the commodity definition..
Insects – Diptera (flies)			
Atherigona orientalis	No	2006 IHS, Australian IRA, 42, CABI horizon scan (9)	Diptera are mostly secondary pests of ginger, with larvae attacking rhizomes infected by fungi or bacteria. Ginger rhizomes with infestations should have visually detectable damage. They are unlikely to be associated with ginger rhizomes meeting the commodity definition. **See Section 7.5 for a more detailed Diptera Hazard ID assessment**
Atherigona sp.	No (genus)	LIMS	
Bradysia sp.	Yes (genus)	LIMS	
Corynoptera sp.	No (genus)	LIMS	
Dettopsomyia nigrovittata	No	LIMS	
Drosophila busckii	Yes	LIMS	
Drosophila hydei	Yes	LIMS	
Drosophila simulans	Yes	QuanCargo	
Drosophila sp.	Yes (genus)	LIMS	
Eumerus sp.	Yes (genus)	LIMS	
Exaireta spinigera	Yes	LIMS	
Limonia strigivena	No	Australian IRA	
Lycoriella sp.	No (genus)	LIMS	
Megaselia albiclavata	No	LIMS	
Megaselia scalaris	Yes	LIMS	
Megaselia sp.	Yes (genus)	LIMS	
Mimegralla coeruleifrons	No	CABI horizon scan (9)	
Mycetophilidae sp.	Yes (genus)	EPPO	
Paramycodrosophila sp.	No	LIMS	
Phytosciara sp.	No (genus)	LIMS	
Pnyxia scabiei	No	China pest list	
Psychoda sp.	Yes (genus)	LIMS	
Sciara sp.	Yes (genus)	LIMS	
Insects – Hemiptera (bugs)			
Aleurocanthus woglumi	No	CABI horizon scan (9), 50	No Hemiptera were considered to require measures beyond minimum requirements because:
Aleurodicus dispersus	No	CABI horizon scan (9), 51	
Aleurodicus dugesii	No	CABI horizon scan (9)	

	Present in NZ?	Association with *Zingiber*	Further assessment)?
Aspidiella hartii	No	1998 IHS, 2006 IHS, Australian IRA, LIMS, QuanCargo	• they are unlikely to be associated with ginger rhizomes, or • if they are associated with rhizomes they are either ○ present on the surface, e.g. some scales insects and mealybugs, and visually detectable, or ○ associated with damaged or rotting rhizomes, which would not meet the commodity definition **See Section 7.6 for a more detailed Hemiptera Hazard ID assessment**
Aspidiella sacchari	No	Australian IRA	
Aspidiotus destructor	No	1998 IHS, 2006 IHS, Australian IRA, CABI horizon scan (9), 54	
Aulacaspis tubercularis	No	PRA China ginger pests (53), CABI horizon scan (9)	
Ceroplastes rubens	No	CABI horizon scan (9), PRA China ginger pests (53)	
Chrysomphalus dictyospermi	No	PRA China ginger pests (53), CABI horizon scan (9)	
Coccus viridis	No	CABI horizon scan (9)	
Cyrtorhinus lividipennis	No	56, 57, 58, LIMS	
Dysmicoccus brevipes	No	1998 IHS, 2006 IHS, Australian IRA, LIMS, QuanCargo, CABI horizon scan (9)	
Dysmicoccus neobrevipes	No	CABI horizon scan (9)	
Euander lacertosus	No	LIMS	
Ferrisia virgata	No	1998 IHS, 2006 IHS, CABI horizon scan (9), 59, 60	
Formicoccus polysperes	No	Ginger Pest List 20180324	
Hemiberlesia palmae	No	Australian IRA	
Howardia biclavis	No	55	
Icerya seychellarum seychellarum	Yes	Australian IRA	
Maconellicoccus hirsutus	No	CABI horizon scan (9)	
Nipaecoccus nipae	No	CABI horizon scan (9), 61	
Paraputo sp.	No (genus)	Ginger Pest List 20180324	
Parasaissetia nigra	Yes	1998 IHS, Australian IRA	
Pentalonia nigronervosa	No	1998 IHS, Pacific Pest List, CABI horizon scan (9), 52	
Pinnaspis strachani	No	1998 IHS, Australian IRA, CABI horizon scan (9), Pacific Pest List	
Planococcus citri	No	62, 63, 64	
Planococcus minor	No	1998 IHS, Australian IRA	
Pseudaonidia trilobitiformis	No	CABI horizon scan (9)	
Pseudococcus jackbeardsleyi	No	CABI horizon scan (9)	
Pseudococcus sp.	Yes (genus)	LIMS	
Selenaspidus articulatus	No	Australian IRA	
Stephanitis typica	No	CABI horizon scan (9), 65	
Insects – ants (Hymenoptera)			
Camponotus chloroticus	No	Pacific Pest list, 43, 44, 45	Ants are the only Hymenoptera likely to be associated with ginger rhizome. They do not have a biological association with ginger but could be present as hitchhikers. No ants were considered to meet the criteria for measures beyond minimum requirements because: • they are unlikely to be associated with ginger rhizomes meeting the commodity definition;
Cardiocondyla nuda	No	LIMS, 46, 47, 48	
Hypoponera punctatissima	Yes	LIMS	
Linepithema humile	Yes	LIMS	
Monomorium minutum	No	LIMS, QuanCargo	
Nylanderia sp.	Yes (genus)	LIMS	
Nylanderia vaga	No	LIMS, QuanCargo	
Ochetellus glaber	Yes	LIMS	
Odontomachus sp.	No (genus)	LIMS	
Pachycondyla sp.	Yes (genus)	Ginger Pest List 20180324	

	Present in NZ?	Association with *Zingiber*	Further assessment)?
Paratrechina sp.	Yes (genus)	LIMS	• most interceptions are worker ants which could not establish; • the National Invasive Ants Surveillance programme reduces the risk of establishment. **See Section 7.8 for more a detailed ant Hazard ID assessment**
Paratrechina vaga	No	LIMS, QuanCargo	
Pheidole fervens	No	LIMS, QuanCargo, 49	
Pheidole megacephala	Yes	2006 IHS, LIMS	
Polyrhachis sp.	No (genus)	LIMS	
Ponera sp.	Yes (genus)	LIMS	
Strumigenys rogeri	No	LIMS, QuanCargo	
Tapinoma melanocephalum	No	QuanCargo	
Technomyrmex albipes	No	2006 IHS, LIMS	
Tetramorium bicarinatum	Yes	LIMS, QuanCargo	
Tetramorium simillimum	No	LIMS, QuanCargo	
Tetramorium tonganum	No	QuanCargo	
Insects – Lepidoptera (butterflies, moths)			
Agrotis ipsilon	Yes	Australian IRA, China pest list	No Lepidoptera were considered to meet the criteria for measures beyond minimum requirements for one or more of the following reasons: • they are unlikely to be associated with ginger rhizomes; • They are unlikely to be associated with ginger rhizomes meeting the commodity definition even if they are associated with ginger rhizomes; • for climatic reasons they are unlikely to establish in NZ, or form damaging populations if they do; • they are unlikely to have a significant impact if they established in NZ. **See Section 7.7 for more a detailed Lepidoptera Hazard ID assessment**
Conogethes punctiferalis	No	2006 IHS, 27, CABI horizon scan (9), China pest list	
Endrosis sarcitrella	Yes	LIMS	
Hippotion celerio	Yes	QuanCargo, 36, 37, 38, 39, 40	
Leucania stenographa	Yes	LIMS	
Maruca vitrata	No	LIMS, 2006 IHS, QuanCargo, 33, 34, 35	
Opogona cf.regressa	No (*O. regressa*)	LIMS	
Opogona omoscopa	Yes	LIMS	
Opogona regressa	No	Australian IRA, QuanCargo	
Opogona sp.	Yes (genus)	LIMS	
Ostrinia furnacalis	No	28, 29, 30, CABI horizon scan (9)	
Ostrinia nubilalis	No	China pest list	
Piletocera xanthosoma	No	Australian IRA, 31, 32	
Setomorpha rutella	No	LIMS, 41	
Spodoptera exempta	Yes	CABI horizon scan (9)	
Spodoptera exigua	No	China pest list	
Spodoptera frugiperda	No	CABI horizon scan (9)	
Spodoptera litura	Yes	1998 IHS	
Spodoptera sp.	Yes (genus)	LIMS	
Udaspes folus	No	CABI horizon scan (9)	
Insects – crickets (Orthoptera)			
Trigonidium sp.	No (genus)	LIMS	Orthoptera are only likely to be present on ginger rhizomes as hitchhikers. They are unlikely to be associated with ginger rhizomes meeting the commodity definition.
Insects – Psocoptera (bark lice, book lice)			
Ectopsocus sp.	Yes (genus)	LIMS	No Psocoptera were considered to meet the criteria for measures beyond minimum requirements as they are unlikely to be associated with ginger rhizomes meeting the commodity definition. **See Section 7.9 for a more detailed Psocoptera Hazard ID assessment**
Lachesilla sp.	No (genus)	LIMS	
Psoquilla marginepunctata	No	LIMS, 66	
Insects – Thysanoptera (thrips)			
Aeolothrips fasciatus	Yes	LIMS, QuanCargo	Thrips that are plant pests typically feed on tender parts of the plant, such as buds, flowers and new leaves, and are unlikely to be associated with
Frankliniella sp.	Yes (genus)	LIMS	
Sciothrips cardamomi	No	CABI horizon scan (9)	

	Present in NZ?	Association with *Zingiber*	Further assessment)?
			rhizomes. Other groups feed on fungi and could be associated with rotting rhizomes. Thrips are unlikely to be associated with ginger rhizomes meeting the commodity definition.
Insects – Zygentoma (silverfish)			
Ctenolepisma longicaudata	Yes	LIMS	Silverfish are only likely to be present on ginger rhizomes as hitchhikers. They are unlikely to be associated with ginger rhizomes meeting the commodity definition.
Acari (mites)			
Arctoseius sp.	No	LIMS, EPPO	No mites were considered to meet the criteria for measures beyond minimum requirements because: • they are unlikely to be associated with ginger rhizomes, or • if they are associated with rhizomes it is generally damaged or rotting rhizomes, they are unlikely to be associated with ginger rhizomes meeting the commodity definition. **See Section 7.10 for a more detailed mite Hazard ID assessment**
Cosmoglyphus oudemansi	No	LIMS, QuanCargo, 73	
Cosmolaelaps sp.	Yes (genus)	LIMS	
Dendrolaelaps sp.	No (genus)	LIMS	
Gamasellodes sp.	No (genus)	LIMS	
Gymnolaelaps sp.	Yes (genus)	LIMS	
Histiostoma sapromyzarum	No	QuanCargo	
Histiostoma sp.	No (genus)	LIMS	
Lasioseius sp.	No (genus)	LIMS	
Lasioseius subterraneus	No	QuanCargo	
Macrocheles sp.	No (genus)	LIMS	
Neoseiulus barkeri	Yes	LIMS, QuanCargo	
Proctolaelaps sp.	Yes (genus)	LIMS	
Raoiella indica	No	CABI horizon scan (9)	
Rhizoglyphus cf. *robini*	Yes (*R. robini*)	LIMS	
Rhizoglyphus minutus	Yes	LIMS, QuanCargo	
Rhizoglyphus robini	Yes	LIMS	
Rhizoglyphus setosus	No	LIMS	
Rhizoglyphus singularis	No	LIMS	
Rhizoglyphus sp.	Yes (genus)	LIMS	
Rhodacarellus sp.	Yes (genus)	LIMS	
Scheloribates sp.	Yes (genus)	LIMS	
Schwiebea similis	No	LIMS	
Schwiebea sp.	Yes (genus)	LIMS	
Schwiebea zingiberi	No	LIMS, QuanCargo	
Sejus sp.		LIMS	
Tyrophagus communis	Yes	LIMS, QuanCargo	
Tyrophagus javensis	No	LIMS, QuanCargo	
Tyrophagus perniciosus	No	LIMS	
Tyrophagus putrescentiae	Yes	LIMS, QuanCargo	
Tyrophagus sp. nr. *putrescentiae*	?	LIMS	
Uroobovella sp.	Yes (genus)	LIMS	
Molluscs (snails, slugs)			
Arion sp.	Yes (genus)	LIMS	Most molluscs associated with imported ginger rhizome would be present as hitchhikers. No molluscs were considered to meet the criteria for measures beyond minimum requirements because they are unlikely to be associated with ginger rhizomes meeting the commodity definition. **See Section 7.11 for a more detailed mollusc Hazard ID assessment**
Achatina fulica	No	2006 IHS, 89, 90, 91, 92	
Parmarion sp.	No (genus)	LIMS	
Pedinogyra sp.	No (genus)	LIMS	
Quantula striata (syn. *Dyakia striata*)	No	LIMS	
Sarasinula plebeia	No	LIMS	
Subulina sp.	No (genus)	LIMS	
Veronicella leydigi	No	QuanCargo	
Veronicella sp.	No (genus)	LIMS	
Nematodes			
Aphelenchoides bicaudatus	Yes	Australian IRA, 1, 2	

	Present in NZ?	Association with *Zingiber*	Further assessment)?
Aphelenchoides sp.	No (genus)	Pacific Pest list, LIMS	***Pratylenchus zeae* requires further assessment (see Targeted PRA in Section 5.1) as it may meet the criteria for measures beyond the minimum requirements. It may be associated with ginger rhizomes asymptomatically and has the potential to establish and cause economic damage in New Zealand.** No other nematodes were considered to require measures beyond minimum requirements for one or more of the following reasons: • they are infrequently associated with ginger, or unlikely to be associated with ginger rhizomes; • they are external root feeders and unlikely to be present on ginger rhizome meeting the commodity definition; • they are unlikely to establish and/or have significant impacts in NZ for climatic reasons and/or because they are specific to ginger; **See Section 5.2 for a more detailed nematode Hazard ID assessment**
Caloosia longicaudata	No	Australian IRA	
Criconemella denoudeni	No	Pacific Pest list	
Criconemella onoensis	No	Pacific Pest list	
Discocriconemella discolabia	No	Australian IRA	
Ditylenchus sp.	No (genus)	Pacific Pest list	
Helicotylenchus abunaamai	No	2006 IHS, 3	
Helicotylenchus dihystera	Yes	Australian IRA, 2006 IHS	
Helicotylenchus egyptiensis	No	Australian IRA, Ginger Pest List 20180324	
Helicotylenchus erythrinae	Yes	Australian IRA	
Helicotylenchus indicus	No	Australian IRA, 2, 4	
Helicotylenchus mucronatus	No	Australian IRA, 2, 5, 6	
Helicotylenchus multicinctus	No	2006 IHS, 2	
Helicotylenchus sp.	No (genus)	Pacific Pest list	
Hemicriconemoides cocophillus	No	Australian IRA, 2	
Hoplolaimus indicus	No	2006 IHS, 7	
Hoplolaimus seinhorsti	No	Australian IRA, 2, 8	
Macroposthonia denoudeni	No	Australian IRA	
Meloidogyne arenaria	Yes	2006 IHS, Australian IRA, 2	
Meloidogyne hapla	Yes	2006 IHS	
Meloidogyne incognita	Yes	2006 IHS, Australian IRA, EPPO	
Meloidogyne javanica	Yes	2006 IHS, Australian IRA, LIMS, CABI horizon scan (9), 10	
Meloidogyne sp.	Yes (genus)	1998 IHS, Pacific Pest List, EPPO, LIMS	
Mesocriconema onoense	No	Pacific Pest list, Australian IRA, 11	
Paratylenchus sp.	Yes (genus)	Pacific Pest list	
Pratylenchus brachyurus	No	CABI horizon scan (9)	
Pratylenchus coffeae	Yes	CABI horizon scan (9), 2006 IHS, Australian IRA, 12	
Pratylenchus zeae	No	CABI horizon scan (9), 2006 IHS, 2, 13, 14, 15	
Quinisulcius sp.	No (genus)	Pacific Pest list	
Radopholus similis	No	CABI horizon scan (9), 2006 IHS, 2, 16, Australian IRA, LIMS	
Rotylenchulus reniformis	No	CABI horizon scan (9), 2006 HIS, Pacific Pest List, Australian IRA, 2, 17	
Rotylenchulus sp.	No (genus)	Pacific Pest list	
Rotylenchus sp.	Yes (genus)	LIMS	
Scutellonema brachyurus	Yes	2006 IHS, 2	
Sphaeronema sp.	Yes (genus)	Australian IRA	
Xiphinema americanum	Yes	Pacific Pest list	
Xiphinema insigne	No	2006 IHS, 18, 19	
Xiphinema krugi	No	Australian IRA, 20	
Oomycetes			
Globisporangium splendens	Yes	2006 IHS, Australian IRA, Pacific Pest List, 85	No oomycetes were considered to meet the criteria for measures beyond minimum requirements because they cause rot of ginger rhizomes that would
Phytophthora citrophthora	Yes	Ginger Pest List 20180324	

	Present in NZ?	Association with *Zingiber*	Further assessment)?
Phytophthora nicotianae	Yes	2006 IHS	be detected during inspection and therefore they are unlikely to be associated with ginger rhizomes meeting the commodity definition **See Section 7.2 for more oomycete Hazard ID details.**
Pythiogeton ramosum	No	ERS	
Pythium aphanidermatum	No	2006 IHS, Australian IRA, CABI horizon scan (9), 86	
Pythium deliense	No	2006 IHS, CABI horizon scan (9)	
Pythium diclinum	Yes	Australian IRA	
Pythium graminicola	Yes	2006 IHS, Australian IRA	
Pythium myriotylum	Yes	1998 IHS, 2006 IHS, Australian IRA, 87, 88	
Pythium sp.	Yes (genus)	Pacific Pest List, LIMS	
Pythium ultimum	Yes	CABI horizon scan (9)	
Pythium vexans	Yes	2006 IHS, Australian IRA, CABI horizon scan (9)	
Woodlice (Isopoda)			
Armadillidium vulgare	Yes	LIMS	Terrestrial isopods are detritivores and unlikely to be associated with ginger rhizomes meeting the commodity definition.
Porcellionides sp.	Yes (genus)	LIMS	
Spiders			
Achaearanea sp.	No (genus)	LIMS	Spiders do not have a biological association with ginger but could be present as hitchhikers. Spiders are unlikely to remain associated with rhizomes which meet the commodity defintions.
Badumna longinqua	Yes	LIMS	
Cheiracanthium sp.	Yes (genus)	LIMS	
Crossopriza lyoni	No	LIMS, QuanCargo	
Eriophora sp.	Yes (genus)	LIMS	
Hasarius adansoni	Yes	LIMS, QuanCargo	
Steatoda sp.	Yes (genus)	LIMS	
Supunna picta	Yes	LIMS	
Viruses			
Cucumber mosaic virus	Yes	2006 IHS, Australian IRA	Viruses were not assessed further based on the lack of exposure pathway (see section 2.3)., therefore establishment) of viruses from ginger rhizomes is unlikely.
Ginger chlorotic fleck virus	No	2006 IHS, CABI horizon scan (9)	

Key to 'Association with *Zingiber*' sources:

Identifier from table	Details/link
1998 IHS	MPI Import Health Standard: Commodity Sub-class: Fresh fruit/vegetables, Ginger, *Zingiber officinale* from Vanuatu. 29 Jun 1998
2006 IHS	MPI Import Health Standard: Commodity Sub-class: Fresh fruit/vegetables, Ginger, *Zingiber officinale* from Thailand or Papua New Guinea [a separate IHS for each country, both issued 15 Feb 2006]
Pacific Pest List	A list, provided by Fiji and Samoa, of pests and pathogens associated with ginger production in those countries.
China Pest List	A list, provided by China, of pests and pathogens associated with ginger production in China.
Ginger Pest List 20180324	A list of organisms associated with ginger, compiled by MPI Horticultural Imports Team from multiple sources, including others listed here, such as IHSs and country pest lists.
Australian IRA	Australian Government, Department of Agriculture and Water Resources. Final import risk analysis report for fresh ginger from Fiji, January 2013.

	http://www.agriculture.gov.au/SiteCollectionDocuments/ba/plant/2013/gingerfromfiji/Final-IRA-report-ginger-fiji.pdf
LIMS	Laboratory Information Management System (LIMS) interception data. MPI internal database of organisms detected at the New Zealand border on imported commodities and identified by the MPI Plant Health and Enviroment Laboratory.
QuanCargo	MPI internal database of imported commodity consignments. Contains interception of organisms detected on imported commodities.
EPPO	European Plant Protection Organisation (EPPO) interception data (1999 - 2018). EPPO database of organisms detected at EPPO country borders on imported commodities.
ERS	MPI Emerging Risks System.
1	http://www.agriculture.gov.au/SiteCollectionDocuments/ba/plant/2013/islandcabbage/Final-PRA-Island-Cabbage.doc
2	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2618799/pdf/173.pdf
3	file:///C:/Users/McCabeAl/Downloads/%E4%BA%91%E5%8D%97%E6%96%87%E5%B1%B1%E5%9C%B0%E5%8C%BA%E7%83%9F%E8%8D%89%E6%A0%B9%E9%99%85%E5%A4%96%E5%AF%84%E7%94%9F%E7%BA%BF%E8%99%AB%E7%A7%8D%E7%B1%BB%E9%89%B4%E5%AE%9A.pdf
4	https://www.jstage.jst.go.jp/article/jjn1972/22/0/22_0_26/_pdf
5	https://books.google.co.nz/books?id=GAdsEt6dEtwC&pg=PA621&lpg=PA621&dq=Helicotylenchus+mucronatus+Papua+New+Guinea&source=bl&ots=hN8N5MgDBW&sig=J_IOdME-HhjPd-azccFroa3VRJc&hl=en&sa=X&ved=0ahUKEwiv_oCOvr_YAhVHv5QKHcIjD_0Q6AEIODAC#v=onepage&q=Helicotylenchus%20mucronatus%20Papua%20New%20Guinea&f=false
6	http://archives.eppo.int/EPPOReporting/1998/Rse-9803.pdf
7	https://www.cabi.org/isc/datasheet/27521#F9D6250F-3AB8-47B7-9AF6-439F95113FF5
8	http://journals.fcla.edu/nemamedi/article/view/85462/82428
9	CABI horizon scan, list of all potential risks for ginger (all Zingiber) imports to NZ,CABI horizon scan extract_20180319.xlxx
10	https://www.cabi.org/cpc/datasheet/33246/aqb
11	https://books.google.co.nz/books?id=mnfidGUVitoC&pg=PA219&lpg=PA219&dq=Mesocriconema+onoense+Papua+New+Guinea&source=bl&ots=5ZjKEheALz&sig=muS5rLIV1G_6ixEX4ht-XHtvQ48&hl=en&sa=X&ved=0ahUKEwitwaet1cbYAhVFGpQKHV68DpgQ6AEIKTAA#v=onepage&q=Mesocriconema%20onoense%20Papua%20New%20Guinea&f=false
12	https://www.cabi.org/cpc/datasheet/43895/aqb
13	https://link.springer.com/content/pdf/10.1007/s10658-015-0674-z.pdf
14	http://ippc.acfs.go.th/pest/G001/T009/NEM018
15	https://www.assct.com.au/media/pdfs/Ag%2036%20Stirling%20et%20al.pdf
16	http://www.sciencedirect.com/science/article/pii/S1671292708600061
17	http://en.cnki.com.cn/Article_en/CJFDTOTAL-ZWBL198801011.htm
18	http://www.padil.gov.au/maf-border/pest/distribution-maf-border/142625
19	http://www.actazool.org/temp/%7B384B90C9-F28A-470B-B1AE-EC6E5691D136%7D.pdf
20	http://www.tandfonline.com/doi/pdf/10.1080/03014223.1997.9518127
21	CABI: https://www.cabi.org/isc/datasheet/11361
22	https://www.cabi.org/isc/abstract/20143264128

23	http://www.antdiversityindia.com/yahoo_site_admin/assets/docs/On_Epuraea_Erichson_of_Assam_final.16733829.pdf
24	https://www.cabi.org/cpc/datasheet/47191/aqb
25	https://www.cabi.org/cpc/datasheet/51520/aqb
26	https://www.cabi.org/cpc/datasheet/54667/aqb
27	https://www.cabi.org/cpc/datasheet/18825/aqb
28	https://www.cabi.org/cpc/datasheet/38026/aqb
29	https://books.google.co.nz/books?id=7N_LBQAAQBAJ&pg=PA369&lpg=PA369&dq=Ostrinia+furnacalis+ginger+rhizome&source=bl&ots=3tUhbVZpuB&sig=GEzJOx9ns52px2QkhT1d_GDSgMQ&hl=en&sa=X&ved=0ahUKEwjnydjWhLrYAhWIn5QKHZ7IBloQ6AEIKTAA#v=onepage&q=Ostrinia%20furnacalis&f=false
30	http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=6434&context=rtd
31	http://www.padil.gov.au/maf-border/pest/distribution-maf-border/142612
32	http://hbs.bishopmuseum.org/pim/pdf/pim11.pdf
33	https://academic.oup.com/jinsectscience/article/13/1/121/1752677
34	https://naldc.nal.usda.gov/download/48352/PDF
35	https://moet.gov.vu/docs/curriculum/Agriculture/Quarantine%20-%20Notes%20and%20Activities%20(Year%2010).pdf
36	http://www.redalyc.org/html/455/45512540014/
37	http://tpittaway.tripod.com/china/h_cel.htm
38	http://www.troplep.org/TLR/2-1/pdf004.pdf
39	http://ijat-aatsea.com/pdf/v12_n7_2_16_DecemberSpecialissue/104--R.%20Jeenkoed--P.pdf
40	https://scholarspace.manoa.hawaii.edu/bitstream/10125/16064/1/PHES11_202-216.pdf
41	https://books.google.co.nz/books?id=TklhDAAAQBAJ&pg=PA162&lpg=PA162&dq=Setomorpha+rutella+China&source=bl&ots=hyU-nEMO1K&sig=CFsQCbloTamUTnmn-2h0_BCDj7I&hl=en&sa=X&ved=0ahUKEwiavp_SqPTYAhWJWbwKHdpQAFEQ6AEITTAI#v=onepage&q=Setomorpha%20rutella%20China&f=false
42	https://www.cabi.org/cpc/datasheet/7731/aqb
43	https://muse.jhu.edu/article/28529
44	https://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/invertebrates/invasive-invertebrates/antsnz/ant-distribution-data/worldwide/camponotus-chloroticus
45	CABI: https://www.cabi.org/isc/datasheet/112963
46	https://www.antweb.org/description.do?genus=cardiocondyla&name=nuda&rank=species
47	https://www.antweb.org/description.do?genus=cardiocondyla&species=nuda&rank=species&adm1Name=Morobe&countryName=Papua%20New%20Guinea
48	http://antbase.org/ants/publications/21727/21727.pdf
49	http://antwiki.org/wiki/images/f/f9/Eguchi_2004.pdf
50	http://www.australianginger.org.au/wp-content/uploads/2016/08/8.10.1-Ginger-Industry-Biosecurity-Plan.pdf
51	https://www.cabi.org/cpc/datasheet/4141/aqb
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9 Appendix 2 planning for ginger fresh produce IRA

Plan signed off by Director Science and Risk Assessment and Director Plants and Pathways on: 1 March 2019

The exact wording of the risk management question and criteria, as well as the timelines, were amended during the risk analysis process via discussions with the project team and relevant managers. This appendix contains the original plan.

9.1 Plan for ginger fresh produce IRA

Date: 22 February 2019
Name: Karen Pugh, Melanie Newfield
Position: Managers Horticulture Imports and Plants and Pathways Risk Assessment

Purpose of document
The following document outlines the plan for completing an import risk analysis for fresh ginger for consumption. The import risk analysis will be used to review the existing requirements for fresh ginger from a number of countries as well as developing requirements for fresh ginger from China. This document gives a detailed risk management question for the import risk analysis, as well as outlining commodity scope, the approach to assessing the risks and dates for the key milestones. The document also gives the rationale for decisions about the scope and assessment methods.

What is the IHS being developed or reviewed?
The current requirements for fresh ginger for consumption from several different countries (Australia, Fiji, Niue, Papua New Guinea, Samoa, Thailand, Tonga, and Vanuatu) are being

brought into one commodity standard. In addition, requirements are being developed for fresh ginger from China.

Risk management question to risk assessors
Are there any pests which are associated with fresh ginger for consumption and may meet the risk evaluation criteria for targeted or specified measures?

The risk evaluation criteria for targeted or specified measures are:

- The biology of the pest means that the methods used for the minimum requirements do not sufficiently target the pest to reduce the risk to an acceptable level. For example: the pest is tiny, cryptic and hidden therefore not readily detected by standard inspection processes.
- Major consequences to New Zealand are likely from the pest, and therefore a greater reduction in the likelihood of introduction than that achieved by the minimum requirements is required to reduce the risk to an acceptable level

The minimum requirements for fresh ginger for consumption in the new IHS will be:

c) be free from viable regulated pests, soil and other contaminants;
d) be commercially produced export quality fresh ginger;
e) be substantially free from damage, bruising and defects;
f) be packaged in clean and either new or refurbished material;
g) be shipped in a secure manner to prevent contamination by regulated pests; and
h) be accompanied by documentation that meets the requirements of Part 3 *Inspection, Verification and Documentation Requirements* of the Import Health Standard.

Fresh ginger must be sourced from a production site that uses standard commercial cultivation methods including pest-control, harvesting, sorting, cleaning, inspection and packaging.

The NPPO of the exporting country must:

i) sample each homogeneous grower lot of fresh ginger. The minimum sample size for inspection must be based on a 95% confidence level that not more than 0.5% of the units in the lot are infested as set out in ISPM 31. *Methodologies for sampling of consignments Appendix 2*.
j) sample and visually inspect each sample unit according to official procedures in accordance with ISPM 23. *Guidelines for inspection* and ISPM 31. Methodologies for sampling of consignments for all regulated pests required by New Zealand.

Timeline
To allow for IHS completion at the end of June, as proposed, final sign-off of the IRA is planned for 26 April 2019 (see Table 2 for detailed milestones).

Process steps and approach
This work was started in 2018. Ginger for consumption was recognised as a “low risk” commodity, in that previous decisions have concluded all pests managed by “basic”/ minimum requirements, it belongs to a plant family without species of major importance to New Zealand (either crop plants or native plants) and it is grown in different climates from New Zealand. However there is limited supporting documentation. With adding a new

country as well as emerging risks and new pest information, something is needed to check that the minimum requirements are sufficient.

Table 8. Method for risk assessment

Process step	Approach
Step 1: Scoping and commodity description	Workshops with RA/ RM teams. Look at interceptions/ history/ other IHSs/ other country documents? This step is complete.
Step 2a: Hazard identification	Selective hazard ID to look for major pests and pathogens. Wider than normal scope for pest and pathogen types because ginger is a rhizome and grown in contact with soil. No obvious "main sources" e.g. a compendium of ginger diseases, so the search was across a wide range of literature sources. This step is complete.
Step 2b: Evaluation of strength of evidence	Workshop with risk managers to confirm we are interpreting criteria correctly. Agreed that there were a small number of pests and pathogens (nematodes, *Pantoea*) which required some further assessment. Agreed that extended hazard ID is the appropriate risk assessment approach to use. This step is complete.
Step 3: Risk assessment	Extended hazard ID for about 4 species (2 or 3 nematodes and *Pantoea ananatis*). Also some of the species which were considered but didn't meet the threshold need explanation paragraphs for why they don't meet hazard ID criteria.
Step 4: Risk management	There is no separate risk management, pests and pathogens were assessed against proposed minimum requirements.
Step 5: Internal review	RA/ RM/ PHEL
Step 6: External review	Yes for extended hazard IDs, at least nematodes.
Step 7: Final review and signoff	Usual process, signed off by Director Science and Risk Assessment

Key milestones

Table 9. Key milestones.

Sample milestones included	
Inventory of work already done and redraft plan (includes work from risk managers)	19 Feb 2019
Directors of Science and Risk Assessment, and Plant & Pathways Sign off detailed plan	28 Feb 2019
Begin pest risk assessments	1 March 2019
Begin summary paragraphs for pests not requiring assessment	1 March 2019
Complete pest risk assessments	15 March 2019
Complete summary paragraphs	22 March 2019
Begin internal peer review	18 March 2019
Complete internal peer-review	5 April
Begin external expert review	5 April
Complete external expert review	19 April
Begin sign-off process	22 April
Complete IRA sign-off process	26 April

Begin lessons learned process	1 May
Complete lessons learned process (note this step also documents lessons from IHS and so cannot be completed until after the IHS is finalised).	31 July 2019

Key roles and tasks
Lead analyst is also doing the nematodes extended hazard IDs. Other team members are doing *Pantoea ananatis* extended hazard ID and finalising summaries of the hazard identification.

Project monitoring and reporting
Once the plan is approved by the Director of Science and Risk Assessment, and the Director of Plant & Pathways, weekly project team meetings (sometimes including team managers) will be used to monitor progress and report to managers. The meetings will continue until the final sign-off".

Human Resource Implications
Information summarised from original plan, names removed.
The project timeline assumes that the lead analyst can put 50-60% if their time to this work throughout March and slightly less than that until the end of April.

Some other staff members are working on the *Prunus* IRA so resource pressures need to be considered.

Project risks

Table 10a. IRA Project risk register.

Risk	Explanation	Mitigation	Likely outcome if risk is not mitigated
Risk to the Project			
Reprioritisation	Other projects are given a higher priority – either the project as a whole or for individual members of the project team	Have the project plan signed off at Director level so that decisions about priority are made at the appropriate level	Don't meet timeline
Not meeting timeline	The risk assessment work takes longer than expected	Addition of other members to the project team	China affected – trade implications
Risks of the project approach			
Not identifying all pests which meet the criteria	Risk organisms are not identified and assessed and are therefore not considered by risk managers for targeted or specified measures.	Internal and external stakeholder input/review	Limited due to ginger being Zingiberaceae, and there being no NZ natives or economic plants of importance in NZ in this family, which means that there is a lower probability of serious pests for New Zealand associated with ginger.

Signoff:

Version number	**Approved by [relevant directors]:**	**Approval date:**
V 1.0		
Comments:		

9.2 Supporting information for plan

Planning for the risk assessment for fresh ginger for consumption was started in early March 2018. The risk assessment itself was started in early May, but was placed on hold at the end of June 2018 following a major reprioritisation of work.

When the risk assessment was started, a detailed project plan was not part of the usual process. However, completing a detailed project plan has proved useful for other risk assessments, and having a plan approved and signed off by the appropriate Directors is recognised as a "must do" step in the updated risk analysis procedures.

Although much of the work has already been completed, there is sufficient work still remaining that a formal plan is useful. This section of the plan contains information from the planning and hazard identification process conducted in 2018.

Commodity scope

Overall objective for the IHSs for *Zingiber* spp. is:

- New IHS: China
- Review:
    - Australia (*Z. officinale*)
    - Fiji (*Z. officinale*)
    - Niue (*Z. zerumbet*)
    - Papua New Guinea (*Z. officinale*)
    - Samoa (*Z. officinale and Z. zerumbet*)
    - Thailand (*Z. officinale*)
    - Tonga (*Z. zerumbet*)
    - Vanuatu (*Z. officinale)*
- Roll the all the ginger IHS's (*Zingiber officinale* and *Z. zerumbet)* into one commodity standard.

Summary of conclusion of discussions of commodity description:

- Fresh ginger is commercially produced ginger (*Z. officinale* or *Z. zerumbet*) rhizomes, with skin. The ginger rhizome is typically branched, containing yellow flesh covered by a thin brown skin. The commodity does not include roots, leaves, stems, or other plant parts.
    - *Z. officinale* and *Z. zerumbet* look and smell different
        - *Z. officinale* = tuber much cleaner/ smooth
        - *Z. zerumbet* = dry root hairs/ fine roots may be attached
- Products must be clean, free from soil, washed, export quality (that is free from visible disease, damage and defects).

- Production information from China, not elsewhere – likely to vary from country to country (not part of formal commodity description)

Minimum risk management requirements (i.e. the minimum intervention)

a) be free from viable regulated pests, soil and other contaminants;
b) be commercially produced export quality;
c) be substantially free from damage, bruising and defects;
d) be packaged in clean and either new or refurbished material;
e) be shipped in a secure manner to prevent contamination by regulated pests; and
f) be accompanied by documentation that meets the requirements of Part 3 *Inspection, Verification and Documentation Requirements*.

Criteria for evaluating risks

Current IHSs are all "basic". In effect, this means that previous assessments have concluded that all associated pests and pathogens are sufficiently managed with the basic/ minimum requirements, and that there are no pests or pathogens which require targeted or specified measures.

The previous risk management decisions create an expectation among exporting countries and other stakeholders that the requirements will remain "basic" for the existing countries and will also be basic for new countries. However fresh ginger for consumption has had a relatively high non-compliance rate, and there is limited documentation on what the previous decisions were based on.

Therefore some review is needed for pests in existing countries as well as the proposed new country. In particular, this review needs to consider whether there are any pests associated with ginger for consumption which meet the risk evaluation criteria for additional measures.

The risk evaluation criteria are based on the following general policy:

- Minimum requirements may not be considered sufficient to manage the risk for a pest when:
  - The biology of the pest means that the methods used for the minimum requirements do not sufficiently target the pest to reduce the risk to an acceptable level. For example: the pest is tiny, cryptic and hidden therefore not readily detected by standard inspection processes.
  - Major consequences to New Zealand are likely from the pest, and therefore a greater reduction in the likelihood of introduction is required to reduce the risk to an acceptable level. That is, if the biology indicates that the minimum requirements may not sufficiently target the pest, further risk assessment is needed.

Assessment approach – rationale

Ginger for consumption is a lower risk and complexity commodity for the following reasons:

- previous decisions have concluded all pests could be managed by "basic"/ minimum requirements for fresh produce
- it belongs to a plant family without species of major importance to New Zealand (either crop plants or native plants)
- it is grown in different climates from New Zealand

Table 11. Summary of workshop discussions on assessment approach for different pest groups

Pest group	Conclusion from preliminary searches	Actions or discussion for writeup
Nematodes	• Ectoparasites live in the soil and do not enter host tissues • Endoparasites could be present in healthy ginger rhizomes	• Ectoparasites do not require further assessment as they will not be present on ginger that meets the commodity description (free of soil). • Endoparasites – use a selective hazard ID approach to identify endoparasitic nematodes which may meet the risk evaluation criteria.
Scale insects	• Few are likely to be associated with ginger rhizomes. • Any present are likely to be visible.	• No further assessment as managed by minimum requirements.
Beetles	• Many associated with ginger are stored product pests and some may affect a wide range of commodities • Potential for some to feed inside ginger rhizomes	• use a selective hazard ID approach to identify internally feeding beetles which may meet the risk evaluation criteria. • If known significant beetle pests are left off the pest list, ensure the rationale is written up
Lepidoptera	• Potential for some to feed inside ginger rhizomes	• use a selective hazard ID approach to identify internally feeding lepidoptera which may meet the risk evaluation criteria. • If known significant lepidopteran pests are left off the pest list, ensure the rationale is written up
Ants	• Ants are hitchhikers • May be present because of mealybugs • If ants turn up at the border, basic measures are not working • Needs to be further discussion about how many ant interceptions justify contacting exporting countries	• No further assessment as hitchhikers are managed by minimum requirements unless there is a repeated history of non-compliance
Bacteria	• Significant infections causing rot should be visually detectable • Many post-harvest rot bacteria are unlikely to have significant impacts in NZ	• Use selective hazard ID • Most bacteria should be managed by basic measures (impacts not significant enough to warrant targeted/specified measures

		• *Pantoea ananatis* is a significant enough pest to warrant an extended hazard ID
Fungi	• Significant infections causing rot should be visually detectable • Many post-harvest rot fungi are unlikely to have significant impacts in NZ	• Use selective hazard ID • Perhaps use *Ceratocystis fimbriata* as an example of a fungus that is a significant enough pest to warrant an extended hazard ID
Molluscs	• There could be eggs found on the medicinal ginger • Some molluscs could cause human or animal health issues • Likely to be managed by cleaning process and visual inspection	• Use selective hazard ID • Giant African snail or a slug could be a good example to write up as a rationale for molluscs being managed by minimum requirements
Viruses	• Only one identified, causing ginger yellowing • A risk only if rhizome grows	• Consider if further assessment needed once there has been more consideration of the likelihood of accidental propagation
Phytoplasmas	• A risk only if rhizome grows • Aster yellows phytoplasma worth further consideration as an important pathogen	• Consider further once there has been more consideration of the likelihood of accidental propagation
Mites	• Frequently intercepted • Small infestations may not be easily visually detected though likely to be managed by cleaning/drying process	• Use selective hazard ID • If known significant mite pests are left off the pest list, ensure the rationale is written up
Soil pests	• Provide a general summary of the risk of soil-associated pests	• No further assessment as soil excluded from the commodity definition

10 Appendix 3 Glossary of definitions and abbreviations.

BORIC	Biosecurity Organisms Register for Imported Commodities (MPI database)
BRAD	Biosecurity Risk Analysis Database (MPI database)
CASE	Contention Argument Evidence Source
CMI	Composite Match Index, a value which indicates the similarities between a location overseas and New Zealand (Phillips et al. 2018).
CPC	Crop Protection Compendium (CABI database)
Endemic	an animal, plant, pest, or disease that is native to and is not naturally found outside a defined geographical area
Establishment	perpetuation, for the foreseeable future, of an organism or disease within an area after entry
ERS	Emerging Risk System (MPI database)
Exposure	the process of the hazard organism moving from the commodity it arrived on to another host
Exotic	this word has different meanings in different fields, but in this document is defined as an animal, plant, pest or disease that is not indigenous to New Zealand
Indigenous	native; organism originating or occurring naturally in a specified area
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)
Introduced	not indigenous, not native to the area in which it now occurs, having been brought into this area directly or indirectly by human activity
IPPC	International Plant Protection Convention, a 1951 multilateral treaty overseen by the Food and Agriculture Organization that aims to secure coordinated, effective action to prevent and to control the introduction and spread of pests of plants and plant products
ISPM	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
IHS	Import Health Standard

IRA	Import risk analysis, an administrative process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication
MPI	Ministry for Primary Industries, New Zealand
NPPO	National Plant Protection Organisation, official service established by a government to discharge the functions specified by the IPPC
NZOR	New Zealand Organisms Register
QuanCargo	New Zealand border transaction database, detailing commercial consignments and interceptions of pests made by quarantine inspection (MPI).
PEQ	Post entry quarantine
PPIN	Plant Pest Information Network database (MPI)
PRA	Pest risk assessment or Pest risk analysis
Risk	in the context of this document risk is defined as the likelihood of the occurrence and the likely magnitude of the consequences of an adverse event as well as a consideration of uncertainty
Vector	an organism or object that transfers a pest, parasite, pathogen or disease from one area or host to another