United States Department of Agriculture

United States
Department of
Agriculture

Animal and Plant
Health Inspection
Service

January 8, 2021

Version 2

Importation of ginseng (*Panax ginseng* C. A. Mey.) for consumption from the Republic of Korea into the United States and Territories

A Qualitative, Pathway-Initiated Pest Risk Assessment

Agency Contact:

Plant Epidemiology and Risk Analysis Laboratory
Science and Technology
Plant Protection and Quarantine
Animal and Plant Health Inspection Service
United States Department of Agriculture
1730 Varsity Drive, Suite 300
Raleigh, NC 27606

Executive Summary

The Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA) prepared this document to assess pest risks associated with importing commercially-produced root of ginseng, *Panax ginseng* C. A. Mey. (Araliaceae), for consumption from the Republic of Korea into the United States and Territories. Based on the market access request submitted by the Republic of Korea, we considered the pathway to include the following processes and conditions: commodity will be washed prior to export, and contaminants such as leaves, stems, and soil will be removed. The pest risk ratings depend upon the application of all conditions of the pathway as described. Roots produced under different conditions were not evaluated and may have a different pest risk.

Using scientific literature, port-of-entry pest interception data, and information from the government of the Republic of Korea, we developed a list of pests with quarantine significance for the United States that occur in the Republic of Korea (on any host) and are associated with the commodity plant species (anywhere in the world).

The following organisms are candidates for pest risk management because they met the threshold for unacceptable consequences of introduction:

Pest type	Taxonomy	Scientific name	Likelihood of Introduction overall rating
Fungi	Sordariomycetes: Hypocreales	*Ilyonectria leucospermi*	Low
		Ilyonectria mors-panacis	
		Ilyonectria robusta	
	Leotiomycetes: Helotiales	*Sclerotinia nivalis*	Medium

Detailed examination and choice of appropriate phytosanitary measures to mitigate pest risk are addressed separately from this document.

Table of Contents

1. Introduction

1.1. Background

The Plant Epidemiology and Risk Analysis Laboratory of the USDA Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) prepared this document to assess the pest risk associated with the importation of commercially-produced fresh root of ginseng (*Panax ginseng* C.A. Mey.) for consumption from the Republic of Korea (referred to as the export area) into the United States and Territories (referred to as the PRA area).

This is a qualitative risk assessment; the likelihood of pest introduction is expressed as a qualitative rating rather than in numerical terms. This methodology is consistent with guidelines provided by the International Plant Protection Convention (IPPC) in the International Standard for Phytosanitary Measures (ISPM) No. 11, "Pest Risk Analysis for Quarantine Pests" (IPPC, 2019). The use of biological and phytosanitary terms is consistent with ISPM No. 5, "Glossary of Phytosanitary Terms" (IPPC, 2013).

As defined in ISPM No. 11, this document comprises Stage 1 (Initiation) and Stage 2 (Risk Assessment) of risk analysis. Stage 3 (Risk Management) will be covered in a separate document.

1.2. Initiating event

The importation of fruits and vegetables for consumption into the United States is regulated under Title 7 of the Code of Federal Regulations, Part 319.56 (7 CFR §319.56-3). Under this regulation, the entry of ginseng from the Republic of Korea into the PRA area is not authorized. This commodity risk assessment was initiated due to a request by the Republic of Korea, Animal and Plant Quarantine Agency to change the Federal regulation to allow entry (Lee, 2019).

1.3. Determining if a weed risk analysis for the commodity is needed

In some cases, an imported commodity could become invasive in the PRA area. If warranted, the commodity is analyzed for weed risk.

Weed risk analyses are not needed for commodities that are already enterable into the PRA area from other countries, for plant species that are widely established (native or naturalized) or cultivated in the PRA area, or for situations in which the imported plant parts cannot easily propagate on their own or be propagated. We determined that the weed risk of ginseng does not need to be analyzed because *Panax* spp. are already enterable from other countries (APHIS, 2020).

1.4. Description of the pathway

A pathway is "any means that allows the entry or spread of a pest" (IPPC, 2019). In the context of this document, the pathway is the commodity to be imported, together with all the processes the commodity undergoes (from production through importation and distribution) that may have an impact on pest risk. The following description of this pathway focuses on those relevant conditions and processes. The conclusions in this document are therefore contingent on the application of all components of the pathway as described.

1.4.1. Description of the commodity
The specific pathway of concern is the importation of fresh roots of ginseng for consumption. Other plant parts are excluded.

1.4.2. Summary of the production, harvest and post-harvest procedures, and shipping and storage conditions being considered
Production and harvesting procedures in the Republic of Korea have not been specified for consideration in this risk assessment. Before export, ginseng will be washed, and contaminants including leaves, stems and soil will be removed. Shipping and storage conditions have not been specified.

2. Pest List and Pest Categorization

The pest list is a compilation of plant pests of quarantine significance for the PRA area. This includes pests that are both present in the Republic of Korea (on any host) and are known to be associated with ginseng (anywhere in the world). Pests are considered to be of quarantine significance if they are not present in the PRA area, are considered for or under Federal official control, or require evaluation for regulatory action. Consistent with ISPM 5, pests that meet any of these definitions are considered "quarantine pests" and are candidates for analysis. Species with a reasonable likelihood of following the pathway into the PRA area are analyzed to determine their pest risk potential.

2.1. Pest list

In Table 1, we list the quarantine pests that occur in the export area on any host and are associated with the commodity species, whether in the export area or elsewhere. For each pest, we indicate 1) the part of the plant the pest is generally associated with and 2) whether we selected the pest for further analysis. Pests selected for further analysis are those that are likely to remain with the commodity in a viable form following harvesting from the field and prior to any post-harvest processing. We developed this pest list based on the scientific literature, port-of-entry pest interception data, and information provided by the government of the Republic of Korea. Pests in shaded rows were selected for further evaluation, because they are likely to remain associated with the harvested commodity (Table 2); for these pests we also denote U.S. distribution as appropriate.

Table 1. Quarantine pests associated with ginseng (in any country) and present in the Republic of Korea (on any host).

Pest name	Presence in the Republic of Korea	Host association	Plant part(s) [1]	Considered further? [2]
ARTHROPODS				

[1] The plant parts listed are those for the plant species under analysis. If the information has been extrapolated, such as from plant part association on other plant species, we note that.
[2] "Yes" indicates simply that the pest has a reasonable likelihood of being associated with the harvested commodity;

Pest name	**Presence in the Republic of Korea**	**Host association**	**Plant part(s)** [1]	**Considered further?** [2]
COLEOPTERA				
Elateridae				
Ectinus sericeus (Candeze) syn.: *Agriotes sericeus* Candaze	MAFRA, 2018; Proctor et al., 1990	MAFRA, 2018; Proctor et al., 1990	Root (MAFRA, 2018)	No. This is an external feeder and will be removed along with soil and other plant debris. This species is not listed in PestID (2020).
Scarabaeidae				
Holotrichia diomphalia Bates	Proctor et al., 1990	Proctor et al., 1990	Root of *Panax quinquefolium* (Kim et al., 1986)	No. Externally feeding larvae present in soil will be removed along with soil and other plant debris. This species is not listed in PestID (2020).
Holotricha morosa Waterhouse	Proctor et al., 1990	Proctor et al., 1990	Roots of *Panax quinquefolium* (Kim et al., 1986)	No. Externally feeding larvae present in soil will be removed along with soil and other plant debris. This species is not listed in PestID (2020).
Maladera orientalis (Motschulsky) syn.: *Serica orientalis* Motschulsky	Proctor et al., 1990	Proctor et al., 1990	Scarabaeidae feed on ginseng roots (Hausbeck, 2007)	No. Externally feeding larvae present in soil will be removed along with soil and other plant debris. This species is not listed in PestID (2020).
Crambidae				
Ostrinia nubilalis (Hübner) syn.: *Pyrausta nubilalis* Hübner	Proctor et al., 1990 (See section 2.2)	Proctor et al., 1990	Stems and leaves of various host plants (CABI, 2020).	No. Present in the United States (CABI, 2020). Action only to Hawaii (PestID, 2020).
Noctuidae				
Agrotis segetum (Denis & Schiffermüller) syn.: *A. fucosa* Butler	Proctor et al., 1990	Proctor et al., 1990	Larvae feed externally on roots of various host plants (CABI, 2020).	No. Externally feeding larvae present in soil will be removed along with soil and other plant debris.

the level of pest prevalence on the harvested commodity (low, medium, or high) is qualitatively assessed as part of the Likelihood of Introduction assessment (section 3).

Pest name	Presence in the Republic of Korea	Host association	Plant part(s) [1]	Considered further? [2]
Agrotis tokionis Butler	Proctor et al., 1990	Proctor et al., 1990	Stems and leaves of various host plants (Kim et al., 1980).	No. Externally feeding larvae present in soil will be removed along with soil and other plant debris. This species is not listed in PestID (2020).
ORTHOPTERA				
Gryllotalpidae				
Gryllotalpa africana Palisot de Beauvois	MAFRA, 2018; Proctor et al., 1990	MAFRA, 2018; Proctor et al., 1990	Root (MAFRA, 2018)	No. This is an external feeder and will be removed along with soil and other plant debris.
NEMATODES				
Coslenchus costatus (de Man) Siddiqi	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Criconema demani Micoletzky	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Criconemoides komabaensis (Imamura) Taylor	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Criconemoides morgensis Hofmänner	Chung et al., 2004	Chung et al., 2004	Root (Chung et al., 2004)	No. See section 2.2.
Ditylenchus destructor Thorpe	Ohh et al., 1986	Ohh et al., 1986	Root (Ohh et al., 1986)	No. See section 2.2.
Ditylenchus dipsaci (Kuhn) Filipjev	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Hirschmanniella imamuri Sher	Chung et al., 2004; MAFRA, 2018	Chung et al., 2004; MAFRA, 2018	Root (Chung et al., 2004; MAFRA, 2018)	No. See section 2.2.
Meloidogyne arenaria (Neal) Chitwood	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Neolobocriconema serratum Khan and Siddiqi	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Paratylenchus lepidus Raski	Chung et al., 2004	Chung et al., 2004	Root (Chung et al., 2004)	No. See section 2.2.
Scutellonema unum Sher	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Trichodorus similis Seinhorst	Chung et al., 2004	Chung et al., 2004	Root (Chung et al., 2004)	No. See section 2.2.
Tylenchorhynchus crassicaudatus Williams	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.

Pest name	Presence in the Republic of Korea	Host association	Plant part(s) [1]	Considered further? [2]
Tylenchorhynchus mashhoodi Siddiqi and Basir	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Xenocriconemella macrodora (Taylor) De Grisse and Loof	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Xiphinema radicicola Goodey	MAFRA, 2018	MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
FUNGI				
Colletotrichum boninense Moriwaki, Toy. Sato & Tsukib.	Lee et al., 2005	Li et al., 2012	Leaves and fruit (Farr and Rossman, 2019) based on general behavior of this type of anthracnose pathogen.	No. *Colletotrichum boninense* represents a species complex (Damm et al., 2012). Potentially present in the United States, detected in Florida (Tarnowski and Ploetz, 2010). It is unlikely that pathogens in this genus, since they attack aerial parts would be associated with the harvested commodity.
Colletotrichum panacicola Uyeda & S. Takim.	Chung and Bae, 1979; Choi et al., 2011	Choi et al., 2011	Fruit (Choi et al 2011), leaves (Farh et al., 2017a, Choi et al 2011).	No. It is unlikely that the pathogen would be associated with the harvested commodity.
Ilyonectria leucospermi L. Lombard & Crous	Farh et al., 2017a	Farh et al., 2017a	Root (Farh et al., 2017a)	Yes. This pathogen causes root rot (Farh et al., 2017a).
Ilyonectria mors-panacis (A.A. Hildebr.) A. Cabral & Crous	Farh et al., 2019	Lu et al., 2019	Root (Farh et al., 2019)	Yes. This pathogen causes rusty root (Farh et al., 2019).
Ilyonectria robusta (A.A. Hildebr.) A. Cabral & Crous	Farh et al., 2017a	Lu et al., 2019	Root (Farh et al., 2017b)	Yes. See section 2.2.
Phoma panacicola Nakata & S. Takim.	Cho and Shin, 2004; MAFRA, 2018	Cho and Shin, 2004; MAFRA, 2018	Root (MAFRA, 2018)	No. See section 2.2.
Phoma panacis Nakata & S. Takim.	Proctor et al., 1990	Proctor et al., 1990	Stem (Proctor et al., 1990)	No. This pathogen causes stem blight (Proctor et al., 1990). We have no evidence that the pathogen could be associated with the harvested commodity.

Pest name	**Presence in the Republic of Korea**	**Host association**	**Plant part(s)** [1]	**Considered further?** [2]
Phyllosticta panacis Nakata & S. Takim.	Cho and Shin, 2004	Cho and Shin, 2004	Leaves (Farr and Rossman, 2019)	No. This pathogen causes snake-eye spot (Cho and Shin, 2004) in leaves (Farr and Rossman, 2019). It is unlikely to be associated with the harvested commodity.
Rhexocercosporidium panacis Reeleder	Eo and Park, 2013	Lu et al., 2014	Root (Lu et al., 2014)	No. This pathogen causes rusty root (Lu et al., 2014). It is unlikely to follow the pathway. See section 2.2.
Sclerotinia nivalis I. Saito	Cho et al., 2013	Cho et al., 2013	Root (Cho et al., 2013)	Yes. This pathogen causes white rot in roots (Cho et al., 2013).
BACTERIA				
Lysobacter gummosus Christensen and Cook	(Lee et al., 2011)	(Lee et al., 2011)	Root (Lee et al., 2011)	No. See section 2.2.
Pseudomonas veronii Elomari et al.	(Lee et al., 2011)	(Lee et al., 2011)	Root (Lee et al., 2011)	No. See section 2.2.
Rhodococcus erythropolis (Gray and Thornton) Goodfellow and Alderson	(Lee et al., 2011)	(Lee et al., 2011)	Root (Lee et al., 2011)	No. See section 2.2.

2.2. Notes on pests identified in the pest list

Insects

Ostrinia nubilalis (Hübner) (syn.: *Pyrausta nubilalis* Hübner). In 1975, a taxonomic investigation of the *Ostrinia* species present in Korea indicated that *O. nubilalis* was not present there (Park, 1975). Subsequently, Proctor et al. (1990) listed *O. nubilalis* (*P. nubilalis*) as a common pest problem in Korean ginseng production. This report cited a 1984 publication also from Korean ginseng producers (Korea Monopoly Corp., Korea Ginseng and Tobacco Research Inst., and Ginseng Growers Assn. of Korea, 1984). Given the order in which these reports were published it is likely that *O. nubilalis* is present in Korea, but with a high level of uncertainty. Additional information would be needed to lower this uncertainty for a final determination of presence in Korea.

Nematodes

Plant parasitic nematodes present in the root surfaces would likely be removed during the post-harvest washing before export (MAFRA, 2018). Nematodes inhabiting the inside of the root would have very limited ability to disperse into a new environment. Since the intended use of the ginseng root is consumption, we consider this commodity to be a dead-end pathway for the introduction of associated quarantine nematodes.

Ditylenchus destructor Thorpe. This nematode has been reported in the continental United States (CABI, 2020). No Action Required except when destined to Hawaii, Puerto Rico, or territories (AQAS, 2019). Ginseng is grown in the field for 4 to 6 years (MAFRA, 2018). Plants in nematode infested fields show stunted growth, wilting and chlorotic leaves (Chung et al., 2004). Damage to roots caused by this nematode, induces root galls which lead to necrosis (Chung et al., 2004) which renders them unsuitable for harvest.

Ditylenchus dipsaci (Kuhn) Filipjev. This nematode has been reported in the continental United States (CABI, 2020). No Action Required except when destined to Hawaii, Puerto Rico, or territories (AQAS, 2019).

Fungi

Ilyonectria robusta (A.A. Hildebr.) A. Cabral & Crous produces red-skin root (Farh et al., 2017a) and it is likely to follow the pathway. There is one isolated detection in California where the pathogen was detected in *Olea europaea* as the causal agent of black foot disease (Lawrence et al., 2019). There is no evidence of this pathogen being introduced in the United States otherwise, hence this pest is considered of quarantine importance.

Phoma panacicola Nakata & S. Takim. This pathogen causes black rot disease (MAFRA, 2018). Severely infected roots, would die in the field or be unsuitable for harvest. The genus is found in low frequency compared to other soilborne pathogens of ginseng (Eo and Park, 2013). In addition, the intended use of the ginseng root is consumption, therefore we find it unlikely for this pathogen to follow the pathway.

Rhexocercosporidium panacis Reeleder causes reddish brown lesions of various sizes, irregular shapes, and diffuse margins, typical of rusty root disease. The lesions remain superficial, smooth, and limited to the epidermal and peridermal tissues (Lu et al., 2014; Reeleder, 2007). If the disease is detected, farmers will harvest to avoid further damage to the roots (Lee et al., 2011). While this pathogen could be very destructive after inoculation in laboratory experiments (Lu et al., 2014), its frequency in soil samples seems to be relatively low compared to the more aggressive root pathogens (Lu et al., 2019) (i.e.: *Cylindrocarpon sp.* and *Ilyonectria* sp.). In addition, the intended use of the ginseng root is consumption, therefore we find it unlikely for this pathogen to follow the pathway.

Bacteria

Lysobacter gummosus Christensen and Cook. The bacterium is an endophyte that has been associated with rusty root symptoms (Lee et al., 2011). This bacterium produced slight rusty color development when directly inoculated in cut ginseng roots (Lee et al., 2011). This is not a conclusive test of pathogenicity (Cohen, 2017) due to the lack of experimental reproduction and demonstrated pathogenicity in a controlled experiment in whole plant instead of cut roots. We found no additional evidence of this bacterium being pathogenic on ginseng, under laboratory or field conditions. Because the pathogen has never been reported to infect ginseng under field conditions we consider that it is unlikely that it would follow the pathway. Moreover, we found no evidence of this bacterium having pest potential on economically important hosts at risk in the United States. Studies in diverse microbiomes suggest that this organism is not a pathogenic bacterium but rather a commensal bacterium with antifungal properties in soil microbial communities (Exposito, 2013) and animal skin microbiome (Becker and Harris, 2010). *Lysobacter gummosus* reduced powdery mildew disease severity caused by *Didymella bryoniae* in Syrian oil pumpkin when applied in combination with other bacteria (Fürnkranz et al., 2012). There are numerous studies that confirm that the genus *Lysobacter* including *L. gummosus* comprises species with potential application as biocontrol agents (Puopolo et al., 2018).

Pseudomonas veronii Elomari et al. The bacterium is an endophyte that has been associated with rusty root symptoms (Lee et al., 2011; Choi et al., 2005). This bacterium produced severe rusty color development when directly inoculated to cut ginseng roots (Lee et al., 2011). This is not a conclusive test of pathogenicity (Cohen, 2017) due to the lack of experimental reproduction and demonstrated pathogenicity in a controlled experiment in whole plant instead of cut roots. Because the pathogen has never been reported to infect ginseng under field conditions we consider that it is unlikely that it would follow the pathway. Moreover, we found no evidence of this bacterium having pest potential on economically important hosts at risk in the United States. This bacterium showed suppressive qualities against potato pathogenic fungi and the pathogens *Achlya klebsiana* and *Pythium spinosum* in rice (Berg and Hallmann, 2006). *Pseudomonas veronii*, after seed inoculation inhibited the growth of *B. cinerea* and *P. syringae pv. tomato* in vitro and reduced leaf damage caused by *B. cinerea* (Romero et al., 2016).

Rhodococcus erythropolis (Gray and Thornton) Goodfellow and Alderson, and *R. globerulus* Goodfellow et al. These bacteria produced mild rusty color development when directly inoculated to cut ginseng roots (Lee et al., 2011). This is not a conclusive test of pathogenicity (Cohen, 2017) due to the lack of experimental reproduction and demonstrated pathogenicity in a controlled experiment in whole plant instead of cut roots. Because the pathogen has never been reported to infect ginseng under field conditions we consider that it is unlikely that it would follow the pathway. Moreover, we found no evidence of this bacterium having pest potential on economically important hosts at risk in the United States. In a whole plant study, *R. erythropolis* markedly reduced the pathogenicity of *Pectobacterium carotovorum* subsp. *carotovorum* in potato tubers, indicating its potential as a biocontrol agent (Uroz et al., 2005). Bacteria in the genus *Rhodococcus*, and in particular *R. erythropolis* have physiological traits of biocontrol agents (Latour et al., 2013). Similarly, *R. globerulus* has plant growth-promoting activities and confer plant resistance to pathogens (Alvarez, 2019).

2.3. Pests considered but not included on the pest list

2.3.1. Organisms with non-quarantine status

We found evidence of organisms that are associated with ginseng, and are present in the export area, but are not quarantine significant for the PRA area. These organisms are listed in the Appendix.

<u>2.3.2. Quarantine pests with weak evidence for association with the commodity or for presence in the export area</u>

Nematodes:

Ogma serratum (Khan and Siddiqi) Raski & Luc, is reported to occur in the Republic of Korea as a pest of *P. ginseng* (Cho and Shin, 2004). This book listed organisms present in Korea associated with diverse species including ginseng, without any mention of damage. We were unable to find additional evidence of this nematode infecting or being associated with ginseng therefore we did not include it in Table 1.

Fungi:

Fusarium redolens Wollenw. Widespread distribution in Asia (Farr and Rossman, 2019). Even though it is highly likely that *F. redolens* is present in ginseng farms in the exporting area, we have no evidence that the pathogen occurs in the Republic of Korea. The pathogen causes root rot in ginseng (Guan et al., 2014) and vascular wilts, crown rot, damping-off in numerous plant species (Farr and Rossman, 2019), therefore it is likely to follow the pathway. While there was a detection in California, Minnesota, and Wisconsin there is no evidence of this pathogen being established in the United States otherwise. A pest assessment would likely conclude that there is a low risk of introduction for this pest like other soil pathogens associated with ginseng in the Nectriaceae family (see section 3.2.1).

Fusarium torulosum (Berk. & M.A. Curtis) Nirenberg, is a species within the species complex of *F. sambucinum* (Nirenberg, 1995) which is present in the Republic of Korea (Lee, 2004). Even though it is highly likely that *F. torulosum* is present in ginseng farms in the exporting area, we have no evidence that the pathogen occurs in the Republic of Korea. The pathogen causes either red-skin disease or root rot depending on the environmental conditions. (Lu et al., 2019) and it would be likely to follow the pathway. There is one detection of *F. sambucinum* in Michigan in potato however, the pathogen is not considered established. A pest assessment would likely conclude that there is a low risk of introduction for this pest like other soil pathogens associated with ginseng in the Nectriaceae family (see section 3.2.1).

Sclerotinia panacicola: sclerotinia rot in ginseng root (Han et al., 2017; Cho et al., 2013) is reported in the Republic of Korea (Cho and Shin, 2004). *Sclerotinia panacicola* is not an accepted taxon so it is uncertain what pathogen may cause the sclerotinia rot identified in this body of work.

Mollusks:

We found evidence that terrestrial mollusks are potentially damaging pests in ginseng production in the Republic of Korea. However, based on their life history, they would not be associated with harvested ginseng roots for consumption. We did not consider them further in this PRA. The mollusk species that may be considered actionable in the United States are reported as: *Acusta despecta sieboldiana* (L. Pfeiffer) (Kim et al., 2008), *Bradybaena sieboldiana* Pfeifer (Proctor et al., 1990), and *Deroceras varians* A. Adams (Kim and Ohh, 1990). Although Proctor et al. (1990) listed *Limacella agrestisuarians* Adams as a pest of ginseng in the Republic of Korea, we found no other records of a mollusk species with this name.

<u>2.3.3. Organisms identified only to the genus level</u>
For this risk assessment, we found evidence that the following organisms identified only to the genus level are reported on *Panax ginseng* in the Republic of Korea: *Holotrichia* sp. (Coleoptera: Scarabaeidae) (Kim et al., 2008); *Ascochyta* sp. [Dothideomycetes: Pleosporales] (Han et al., 2017; Farr and Rossman, 2019), *Cladosporium* sp. [Dothideomycetes: Capnodiales] (Farr and Rossman, 2019), *Dactylonectria* sp. [Sordariomycetes: Hypocreales] (Farr and Rossman, 2019), *Erysiphe* sp. (Leotiomycetes: Erysiphales) and *Macrophoma* sp. (Dothideomycetes: Botryosphaeriales) (Farr and Rossman, 2019).

In commodity import risk assessments, the taxonomic unit for pests selected for evaluation beyond the pest categorization stage is usually the species (IPPC, 2013). We generally do not assess risk for organisms identified only to the genus level, particularly if the genus in question is reported in the PRA area. Many genera contain multiple species, and we cannot know if the unidentified species occurs in the PRA area and, consequently, if it is regulated in the PRA area. However, if the genus in question is absent from the PRA area, the genus can be regulated. Because the organism has not been fully identified, however, we cannot properly assess the likelihood and consequences of its introduction. We list those genera here so that risk managers may determine if measures beyond those intended to mitigate fully identified pests are warranted.

2.4. Pests selected for further analysis

We identified 4 quarantine pests for further analysis (Table 2).

Table 2. Pests selected for further analysis.

Pest type	Taxonomy	Scientific name
Fungi	Sordariomycetes: Hypocreales	*Ilyonectria leucospermi*
		Ilyonectria mors-panacis
		Ilyonectria robusta
	Leotiomycetes: Helotiales	*Sclerotinia nivalis*

3. Assessing Pest Risk Potential

3.1. Introduction

For each pest analyzed, we estimate its overall pest risk potential. Risk is described by the likelihood of an adverse event, the potential consequences, and the uncertainty associated with these parameters. For each pest, we determine if there is an endangered area within the PRA area. The endangered area is defined as the area where ecological factors favor pest establishment and where pest presence will likely result in economically important losses. If a pest causes an unacceptable impact (i.e., is a threshold pest), that means it will adversely affect agricultural production (e.g., causes 10 percent or greater yield loss, increases production costs, etc.), an environmentally important host, or international trade. Once an endangered area has been determined, the overall risk of each pest is then determined by assessing the likelihood of its introduction into the endangered area on the imported commodity.

The likelihood of introduction is based on the likelihoods of entry and establishment. We qualitatively assess risk using the ratings Low, Medium, and High. The risk factors comprising the likelihood of introduction are interdependent; therefore, the model is multiplicative rather than additive. We define the different risk categories as follows:

High: Pest introduction is highly likely to occur.

Medium: Pest introduction is possible, but for that to happen, the exact combination of required events needs to occur.

Low: Pest introduction is unlikely to occur because one or more of the required events are unlikely to happen or because the full combination of required events is unlikely to align properly in time and space.

Uncertainty is addressed within the assessment as follows:

Negligible uncertainty: Additional or better evidence is very unlikely to change the rating.

Low uncertainty: Additional or better evidence probably will not change rating.

Moderate uncertainty: Additional or better evidence may or may not change rating.

High uncertainty: Reliable evidence is not available.

3.2. Assessment results

3.2.1. *Ilyonectria leucospermi* L.; *I. mors-panacis* (A.A. Hildebr.) A. Cabral & Crous and *I. robusta* (A.A. Hildebr.) A. Cabral & Crous (Sordariomycetes: Hypocreales); formerly *I. radicicola* species complex (Cabral et al., 2012; Farh et al., 2017a)

Root-rot and rusty root diseases are the most dangerous diseases for ginseng crops as they cause a great decrease in yield and damage root shape and quality in plants of all ages (Farh et al., 2017a; Farh et al., 2019). The disease is detected at all stages of plant growth. *Ilyonectria leucospermi*, *I. mors-panacis* and *I. robusta* overwinter in the soil in a resting stage, so that newly planted crops and existing crops can be re-invaded each season (Farh et al., 2017a).

Defining the endangered area for *Ilyonectria leucospermi, I. mors-panacis and I. robusta* within the United States and Territories

Climatic suitability	*Panax ginseng* is cultivated throughout the Republic of Korea (MAFRA, 2018) which encompasses Plant Hardiness Zones (PHZ) 5-9 (Takeuchi et al., 2018). Based on the high prevalence of root rot disease caused by this group of pathogens (Farh et al., 2019; Farh et al., 2017a) in the Republic of Korea, areas in the United States in these PHZ would be climatically suitable for *I. leucospermi*, *I. mors-panacis* and *I. robusta*. Distribution records of these three fungal species suggest that the endangered area could extend to PHZ 2-12 however, due to the uncertainty on the specific location where the pathogen was detected, this range of PHZ may overestimate the climate suitability area [i.e.: *I. mors-panacis* is found in

	Ontario, Canada (Agustí-Brisach et al., 2016) includes PHZ 2-5 and *I. leucospermi* is found in Western Cape Province, South Africa (Lombard et al., 2013)].
Hosts in PRA Area	*Ilyonectria leucospermi*, *I. mors-panacis* and *I. robusta* infect widely available hosts in the United States that grow in climatically suitable areas for the development of these pathogens (NRCS, 2020). *Ilyonectria leucospermi*: *Leucospermum* sp. and *Protea* sp. [Proteaceae] (Lombard et al., 2013). *Ilyonectria mors-panacis*: *P. quinquefolium* [Araliaceae] (Cabral et al., 2012). *Ilyonectria robusta*: *P. quinquefolium* [Araliaceae], *Prunus cerasus* [Rosaceae], *Quercus robur* [Fagaceae], *Quercus* sp. [Fagaceae], *Thymus sp*. [Lamiaceae], *Vitis vinifera* (basal end of rootstock) [Vitaceae], *Tilia petiolaris* [Tiliaceae] (Cabral et al., 2012); *Eriobotrya japonica* [Rosaceae] (Agustí-Brisach et al., 2016); *Gastrodia elata* [Orchidaceae] (Qiao et al., 2019); *Juglans regia* [Juglandaceae] (Mora-Sala et al., 2018).
Economically important hosts at risk[a]	The host range of these three pathogens comprises economically significant crops, such as sour cherries, grapevines and European walnut which are grown in large acreages throughout the United States (NASS, 2020). *Panax quinquefolius* is listed as an endangered species in Maine, threatened in Michigan and New Hampshire, as a species of special concern in Connecticut, Massachusetts and North Carolina and as exploitably vulnerable in New York (NRCS, 2020).
Pest potential on economically important hosts at risk	These pests are likely to cause unacceptable consequences they cause root rot and consequently plant loss at any stage of the crop cycle (Lombard et al., 2013; Mora-Sala et al., 2018; Proctor et al., 1990; Qiao et al., 2019). *Ilyonectria leucospermi* causes black foot rot in *Leucospermum* sp., and *Protea* sp. in nursery and plantation (Lombard, 2013). The persistence of *I. mors-panacis* in soils for decades increases the possibility of ginseng crop loss (Farh et al., 2019). *Ilyonectria robusta* causes dry rot in roots, necrosis in the xylem and cankers in branches of *Pyrus communis* (Sessa Jusid, 2016). In *Eriobotrya japonica* it causes decline due to root rot, affecting development and leading to plant death in new and mature plantations (Agustí-Brisach et al., 2016).
Defined Endangered Area	Based on the host range and climates where *I. leucospermi*, *I. mors-panacis* and *I. robusta* are reported, the endangered area in the United States would comprise Plant Hardiness Zones 3-11 and could potentially extend to PHZ 2-12.

[a] As defined by ISPM No. 11, supplement 2, “economically” important hosts refers to both commercial and non-market (environmental) plants (IPPC, 2013).

Assessing the likelihood of introduction of *I. leucospermi*, *I. mors-panacis* and *I. robusta* into the endangered area via ginseng imported from the Republic of Korea

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of Entry			
Pest prevalence on the harvested commodity	High	Low	*Ilyonectria leucospermi*, *I. mors-panacis* and *I. robusta* overwinter in the soil in a resting stage, so that newly planted crops and existing crops can be re-invaded each season (Farh et al., 2017a; Lu et al., 2019), root rot disease is detected at all stages of plant growth ages (Farh et al., 2017a; Lu et al., 2019). These pathogens are highly likely to be associated with the harvested commodity.
Likelihood of surviving post-harvest processing before shipment	Medium	Low	If the disease is far enough progressed, signs and symptoms of *I. leucospermi*, *I. mors-panacis* and *I. robusta* infection (e.g. rotted roots) would result in plant loss in the field or render the roots unsuitable for harvest. This would make the rating for this risk element low for this pest. However, since early stage infections would not be detectable, the rating for this risk element was decreased by only one level from High to Medium with Low uncertainty.
Likelihood of surviving transport and storage conditions of the consignment	Medium	Low	Germination and mycelial growth of *I. mors-panacis* and *I. robusta* occur between 4°C - 30°C with optimum growth occurring at 18°C and 22°C respectively (Cabral et al., 2012; Farh et al., 2017a). Species of this fungal complex cause damages in ginseng fields throughout the growing season (Ohh, 1981) suggesting that the spores or mycelia remain viable over a broad range of environmental conditions. Ginseng roots are stored at 3°C-8°C (MAFRA, 2018). Cool temperatures during storage and transport may slow the growth of the pathogen but are not likely to eliminate it. Thus, the rating remains the same.
Overall Likelihood of Entry	Medium		

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of Establishment	Low	Medium	*Ilyonectria* spp. produce resilient chlamydospores (Cabral et al., 2012) that survive adverse environmental conditions. These pathogens can persist for years in soil (Farh et al., 2019; Farh et al., 2017a; Farh et al., 2017b; Lu et al., 2019). These soil fungi can be dispersed with nursery stock (Mora-Sala et al., 2018), by water, insects and farm equipment. Discarded infested ginseng roots could introduce *I. mors-panacis*, *I. leucospermi* and *I. robusta* into soil. However, since ginseng roots will be imported for consumption, the likelihood of these pathogens coming into contact with host material and establishing in the soil in the United States is considered Low with Medium uncertainty.
Likelihood of Introduction (combined likelihoods of entry and establishment)	Low		

3.2.2. *Sclerotinia nivalis* I. Saito (Leotiomycetes: Helotiales)

Sclerotinia nivalis causes white rot in ginseng roots (Cho et al., 2013). *Sclerotinia* infection in ginseng roots starts by causing discoloration in the epidermis and rotting (Wang et al., 2017; Lee, 2004), eventually leading to plant loss (Cho et al., 2013).

Defining the endangered area for *Sclerotinia nivalis* within the United States and Territories

Climatic suitability	*Sclerotinia nivalis* is reported from China (Fu et al., 2012), Korea (Cho et al., 2013; Lee, 2010) and Japan (Hokkaido; Plant Hardiness Zones 4-6) (Saito, 1997). In China, *S. nivalis* has only been found in the north-western area of Hubei Province (Plant Hardiness Zone 7) (Fan et al., 2012). *Sclerotinia nivalis* is a "snow mold" meaning that is able to remain active under low temperatures (Hoshino et al., 2009). Based on its current distribution, Plant Hardiness Zones 2-8 in the United States would be climatically suitable for *S. nivalis* (Takeuchi et al., 2018).
Hosts in PRA Area	*Sclerotinia nivalis* is reported in a wide range of hosts: *Arctium lappa* (burdock) [Asteraceae], *Chrysanthemum morifolium* [Asteraceae], *Ambrosia elatior* [Asteraceae], *Angelica acutiloba* [Apiaceae], *Ajuga reptans* [Lamiaceae], *Daucus carota* [Apiaceae], *Plantago lanceolata* [Plantaginaceae] (Saito, 1997), *Lactuca sativa* [Asteraceae] (Li et al., 2000), *Aralia elata* [Araliaceae] (Lee, 2010), *Atractylodes japonica* [Asteraceae] (Zhou et al., 2015), *Pulsatilla koreana* [Ranunculaceae] (Fu

	et al., 2012), *Sedum sarmentosum* (whorled stonecrop - a widely planted ornamental) [Crassulaceae] (Fan et al., 2012). Many of these hosts are widely distributed or grown in areas of the United States that would be climatically suitable for establishment of this fungi (NRCS, 2020).
Economically important hosts at risk[a]	The host range of *S. nivalis* comprises economically significant crops, such as carrot and lettuce which are grown in large acreages throughout the United States (NASS, 2020), and also important ornamental species such as sedum and ajuga.
Pest potential on economically important hosts at risk	On lettuce, *S. nivalis* causes a disease called "lettuce drop" (Li et al., 2000). On carrot, it causes a crown rot which extends into the roots and foliage (Saito, 1997). Diseases caused by *S. nivalis* render these vegetables unmarketable.
Defined Endangered Area	Based on the host range and climates where *S. nivalis* is reported, the endangered area in the United States would comprise Plant Hardiness Zones 2-8.

[a] As defined by ISPM No. 11, supplement 2, "economically" important hosts refers to both commercial and non-market (environmental) plants (IPPC, 2013).

Assessing the likelihood of introduction of *S. nivalis* into the endangered area via ginseng imported from the Republic of Korea

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of Entry			
Pest prevalence on the harvested commodity	High	Low	*Sclerotinia nivalis* causes white rot on ginseng roots (Cho et al., 2013). Infected roots have a brownish watery soft rot and black sclerotia which vary in shape, and are often produced on rotten roots. Leaf symptoms include wilting foliage which becomes discolored and desiccated. The disease produces plant loss (Cho et al., 2013).
Likelihood of surviving post-harvest processing before shipment	Medium	Low	If the disease is far enough progressed, signs and symptoms of *S. nivalis* infection (e.g. rotted roots) would result in plant loss in the field or render the roots unsuitable for harvest. This would make the rating for this risk element low for this pest. However, since early stage infections would not be detectable, the rating for this risk element was decreased by only one level from High to Medium with Low uncertainty.

Risk Element	Risk Rating	Uncertainty Rating	Evidence for rating (and other notes as necessary)
Likelihood of surviving transport and storage conditions of the consignment	High	Low	*Sclerotinia nivalis* is considered a "snow mold" pathogen and is able to remain active under low temperatures (Hoshino et al., 2009). It is likely to survive and continue infecting ginseng roots under cold storage or transport conditions; therefore the risk rating increases to High.
Overall Likelihood of Entry	High		
Likelihood of Establishment	Low	Medium	*Sclerotinia nivalis* is not able to move on its own. It is most likely to be spread to new areas when its sclerotia (hardened survival structures, similar in shape and size to a grain of rice) are moved in debris or soil (Saito, 1997; Li et al., 2000). Based on this evidence and since ginseng roots will be imported for consumption, the likelihood of *S. nivalis* coming into contact with host material and establishing in the soil in the United States is considered Low with Medium uncertainty.
Likelihood of Introduction (combined likelihoods of entry and establishment)	Medium		

4. Summary and Conclusions of Risk Assessment

Of the organisms associated with ginseng worldwide and present in the export area, we identified 4 organisms that are quarantine pests for the PRA area, are likely to exceed the threshold for unacceptable consequences in the PRA area, and have a reasonable likelihood of following the commodity pathway (Table 3). Thus, these pests are candidates for risk management. These results represent a baseline estimate of the risks associated with the import commodity pathway as described in section 1.4.

Table 3. Summary of pests selected for further evaluation and determined to be candidates for risk management. All of these pests meet the threshold for unacceptable consequences of introduction and have a reasonable likelihood of following the commodity pathway.

Pest type	Taxonomy	Scientific name	Likelihood of Introduction overall rating
Fungi		*Ilyonectria leucospermi* *Ilyonectria mors-panacis* *Ilyonectria robusta*	Low

	Leotiomycetes: Helotiales	*Sclerotinia nivalis*	Medium

Detailed examination and choice of appropriate phytosanitary measures to mitigate pest risk are not addressed in this document.

5. Literature Cited

7 CFR § 319.56-3. 2012. U.S. Code of Federal Regulations, Title 7, Part 319.56-3 (7 CFR § 319.56-3 - General requirements for all imported fruits and vegetables). https://www.gpo.gov/fdsys/granule/CFR-2012-title7-vol5/CFR-2012-title7-vol5-sec319-56-3.

Agustí-Brisach, C., A. Cabral, E. González-Domínguez, A. Pérez-Sierra, M. León, P. Abad-Campos, J. García-Jiménez, H. Oliveira, and J. Armengol. 2016. Characterization of *Cylindrodendrum*, *Dactylonectria* and *Ilyonectria* isolates associated with loquat decline in Spain, with description of *Cylindrodendrum alicantinum sp. nov*. European Journal of Plant Pathology 145(1):103-118.

Alvarez, H. M. 2019. Biology of *Rhodococcus*. Springer International Publishing.

APHIS. 2020. Fruits and Vegetables Import Requirements (FAVIR). United States Department of Agriculture, Animal and Plant Health Inspection Service (APHIS). https://epermits.aphis.usda.gov/manual/.

AQAS. 2019. Pest Interception Database (PestID). Agricultural Quarantine Activity Systems (AQAS). Animal and Plant Healt Inscpection Service (APHIS). United States Department of Agriculture (USDA).

Becker, M. H., and R. N. Harris. 2010. Cutaneous bacteria of the redback salamander prevent morbidity associated with a lethal disease. Plos One 5(6).

Berg, G., and J. Hallmann. 2006. Control of plant pathogenic fungi with bacterial endophytes. Pages 53-69 Microbial root endophytes. Springer.

Bernhart. 2018. Plant Parasitic Nematodes in Sustainable Agriculture of North America. [S.l.] : Springer International Publishing, 2018., S.l.

CABI. 2019. Crop Protection Compendium. Commonwealth Agricultural Bureau International (CABI). http://www.cabi.org/cpc/.

CABI. 2020. Crop Protection Compendium. Centre for Agriculture and Bioscience International (CABI). https://www.cabi.org/cpc/.

Cabral, A., J. Z. Groenewald, C. Rego, H. Oliveira, and P. W. Crous. 2012. *Cylindrocarpon* root rot: multi-gene analysis reveals novel species within the *Ilyonectria radicicola* species complex. Mycological Progress 11(3):655-688.

Cho, H. S., J.-S. Shin, J.-H. Kim, T.-K. Hong, D.-H. Cho, and J. Y. Kang. 2013. First report of sclerotinia white rot caused by *Sclerotinia nivalis* on *Panax ginseng* in Korea. Research in Plant Disease 19(1):49-54.

Cho, W.-D., and H.-D. Shin. 2004. List of plant diseases in Korea. Korean Society of Plant Pathology.

Choi, J.-E., J.-A. Ryuk, J.-H. Kim, C.-H. Choi, J.-S. Chun, Y.-J. Kim, and H.-B. Lee. 2005. Identification of endophytic bacteria isolated from rusty-colored root of Korean ginseng (*Panax ginseng*) and its induction. Korean Journal of Medicinal Crop Science 13(1):1-5.

Choi, K.-J., W.-G. Kim, H.-G. Kim, H.-W. Choi, Y.-K. Lee, B.-D. Lee, S.-Y. Lee, and S.-K. Hong. 2011. Morphology, molecular phylogeny and pathogenicity of *Colletotrichum* *panacicola* causing anthracnose of Korean ginseng. The Plant Pathology Journal 27(1):1-7.

Chung, H.-S., and H.-W. Bae. 1979. Ginseng anthracnose in Korea. Factors affecting primary inoculum, growth of the pathogen, disease development and control. Korean journal of applied entomology 18(1):35-41.

Chung, K.-C., S.-D. Park, Z. Khan, and B.-J. Kim. 2004. A survey for plant-parasitic nematodes associated with ginseng (*Panax ginseng* CA Meyer). Korean Journal of Medicinal Crop Science 12(5):355-359.

Cohen, J. 2017. The Evolution of Koch's Postulates. Pages 1-3. e1 Infectious Diseases. Elsevier.

Damm, U., P. F. Cannon, J. Woudenberg, P. Johnston, B. Weir, Y. Tan, R. Shivas, and P. Crous. 2012. The *Colletotrichum boninense* species complex. Studies in mycology 73:1-36.

Dong, G. K., G. L. Soon, K. L. Young, P. L. Jong, and C. J. Ki. 2004. Root rot of *Panax ginseng* caused by *Serratia liquefaciens*. Research in Plant Disease 10(1):8-12.

Eo, J., and K.-C. Park. 2013. Effects of manure composts on soil biota and root-rot disease incidence of ginseng (*Panax ginseng*). Applied Soil Ecology 71:58-64.

Exposito, R. G. 2013. Role of antagonistic *Lysobacter* species and their bioactive compounds in suppression of plant diseases.

Farh, M. E.-A., J. A. Han, Y.-J. Kim, J. C. Kim, P. Singh, and D.-C. Yang. 2019. Discovery of a new primer set for detection and quantification of *Ilyonectria mors-panacis* in soils for ginseng cultivation. Journal of Ginseng Research 43(1):1-9.

Farh, M. E.-A., Y.-J. Kim, Y.-J. Kim, and D.-C. Yang. 2017a. *Cylindrocarpon destructans*/*Ilyonectria radicicola*-species complex: Causative agent of ginseng root-rot disease and rusty symptoms.

Farh, M. E.-A., Y.-J. Kim, Y.-J. Kim, and D.-C. Yang. 2018. *Cylindrocarpon destructans*/*Ilyonectria radicicola*-species complex: Causative agent of ginseng root-rot disease and rusty symptoms. Journal of Ginseng Research 42(1):9-15.

Farh, M. E.-A., Y.-J. Kim, P. Singh, and D.-C. Yang. 2017b. Cross interaction between *Ilyonectria mors-panacis* isolates infecting Korean ginseng and ginseng saponins in correlation with their pathogenicity. Phytopathology 107(5):561-569.

Farr, D. F., and A. Y. Rossman. 2019. Fungal Databases, U.S. National Fungus Collections, Agricultural Research Service, United States Department of Agriculture. https://nt.ars-grin.gov/fungaldatabases/.

Fürnkranz, M., B. Lukesch, H. Müller, H. Huss, M. Grube, and G. Berg. 2012. Microbial diversity inside pumpkins: microhabitat-specific communities display a high antagonistic potential against phytopathogens. Microbial ecology 63(2):418-428.

GBIF. 2020. GBIF Backbone Taxonomy: Ocurrences of Criconemoides informis Micoletzky. Global Biodiversity Information Facility (GBIF).

Guan, Y., B. Lu, Y. Wang, J. Gao, and L. Wu. 2014. First report of root rot caused by *Fusarium redolens* on ginseng (*Panax ginseng*) in Jilin province of China. Plant Disease 98(6):844-844.

Guan, Y. M., J. C. Deng, Y. Y. Ma, Y. Li, and Y. Y. Zhang. Seed Associated Fungal Diversity and the Molecular Identification of *Fusarium* with Potential Threat to Ginseng (*Panax ginseng* Meyer) in China. Plant Disease (ja).

Han, J.-H., G.-C. Park, and K. S. Kim. 2017. Antagonistic evaluation of *Chromobacterium* sp. JH7 for biological control of ginseng root rot caused by *Cylindrocarpon destructans*. Mycobiology 45(4):370-378.

Hausbeck, M. K. 2007. Pest Management in the Future: A Strategic Plan for the Michigan and Wisconsin Ginseng Industry. Michigan State University. 64 pp.

IPPC. 2013. International Standards for Phytosanitary Measures, Publication No. 11: Pest Risk Analysis for Quarantine Pests. Food and Agriculture Organization of the United Nations, Secretariat of the International Plant Protection Convention (IPPC), Rome, Italy. 36 pp.

IPPC. 2019. International Standards for Phytosanitary Measures, Publication No. 5: Glossary of Phytosanitary Terms. Food and Agriculture Organization of the United Nations, Secretariat of the International Plant Protection Convention (IPPC), Rome, Italy. 35 pp.

Kilonzo-Nthenge, A., F.-C. Chen, and S. L. Godwin. 2008. Occurrence of *Listeria* and Enterobacteriaceae in domestic refrigerators. Journal of food protection 71(3):608-612.

Kim, H. S., S. H. Kim, and K. M. Choi. 1980. Studies on bionomics and control of cutworms [abstract]. Korean Journal of Plant Protection 19(4):243-249.

Kim, K. H., S. S. Kim, and J. S. Hyun. 1986. External morphology and species components of the white grubs collected from ginseng field and its neighbouring fallows [abstract]. Korean Journal of Plant Protection 24(4):179-182.

Kim, H.-J., S.-S. Cheong, D.-W. Kim, J.-S. Park, J. Ryu, Y.-S. Bea, and S.-J. Yoo. 2008. Investigation into disease and pest incidence of *Panax ginseng* in Jeonbuk province. Korean Journal of Medicinal Crop Science 16(1):33-38.

Korea Monopoly Corp., Korea Ginseng and Tobacco Research Inst., and Ginseng Growers Assn. of Korea, 1984. Ginseng: Diseases, insects and color pictures. Korea Monopoly Corp., Shintangin, Korea.

Latour, X., C. Barbey, A. Chane, A. Groboillot, and J.-F. Burini. 2013. *Rhodococcus erythropolis* and its γ-lactone catabolic pathway: an unusual biocontrol system that disrupts pathogen quorum sensing communication. Agronomy 3(4):816-838.

Lawrence, D., M. Nouri, and F. Trouillas. 2019. Taxonomy and multi-locus phylogeny of *Cylindrocarpon*-like species associated with diseased roots of grapevine and other fruit and nut crops in California. Fungal Systematics and Evolution 4(1):59-75.

Lee, C., K.-Y. Kim, J.-E. Lee, S. Kim, D. Ryu, J.-E. Choi, and G. An. 2011. Enzymes hydrolyzing structural components and ferrous ion cause rusty-root symptom on ginseng (*Panax ginseng*). Journal of microbiology and biotechnology 21(2):192-196.

Lee, H.-B., J.-Y. Park, and H.-S. Jung. 2005. Identification, growth and pathogenicity of *Colletotrichum boninense* causing leaf anthracnose on Japanese Spindle Tree. The Plant Pathology Journal 21(1):27-32.

Lee, S.-G. 2004. *Fusarium* species associated with ginseng (*Panax ginseng*) and their role in the root-rot of ginseng plant. Research in Plant Disease 10(4):248-259.

Lee, S.-H., J.-S. Shin, T.-G. Hong, Y.-J. Ahn, and D.-H. Cho. 2010. Biological Characteristics of the Ginseng Stem Fungus Gnat (*Phytosciara procera*) and Its Environmental-friendly Control Using Modified Topping of Ginseng Peduncles. Journal of Ginseng Research 34(1):23-29.

Lee, Y.-G. 2019. Information of PRA of Korean fresh ginseng. Personal communication to P. I. M. USDA-APHIS-PPQ on May 24, 2019, from Y.-G. Lee (Republic of Korea, Animal and Plant Quarantine Agency, Department of Plant Quarantine, Export Management Division, Director).

Li, Z., Y. M. Liang, and C. M. Tian. 2012. Characterization of the causal agent of poplar anthracnose occurring in the Beijing region. Mycotaxon 120(1):277-286.

Lombard, L., C. M. Bezuidenhout, and P. W. Crous. 2013. *Ilyonectria* black foot rot associated with Proteaceae. Australasian Plant Pathology 42(3):337-349.

Lu, X., A. Chen, X. Zhang, X. Jiao, and W. Gao. 2014. First report of *Rhexocercosporidium panacis* causing rusty root of *Panax ginseng* in northeastern China. Plant Disease 98(11):1580-1580.

Lu, X. H., X. M. Zhang, X. L. Jiao, J. J. Hao, X. S. Zhang, Y. Luo, and W. W. Gao. 2019. Taxonomy of fungal complex causing red-skin root of *Panax ginseng* in China. Journal of Ginseng Research.

MAFRA. 2018. PRA Information of Korean Fresh Ginseng. Republic of Korea, Ministry of Agriculture, Food and Rural Affairs (MAFRA), Animal and Plant Quarantine Agency. 10 pp.

Mora-Sala, B., A. Cabral, M. León, C. Agustí-Brisach, J. Armengol, and P. Abad-Campos. 2018. Survey, identification, and characterization of *Cylindrocarpon*-like asexual morphs in Spanish forest nurseries. Plant Disease 102(11):2083-2100.

NASS. 2020. National Agricultural Statistics Service - Quick Stats. United States Department of Agriculture, National Agricultural Statistics Service. https://quickstats.nass.usda.gov/.

Nirenberg, H. I. 1995. Morphological differentiation of *Fusarium sambucinum* Fuckel sensu stricto, *F. torulosum* (Berk. & Curt.) Nirenberg comb. nov. and *F. venenatum* Nirenberg sp. nov. Mycopathologia 129(3):131-141.

NRCS. 2020. Plants Database. Natural Resources Conservation Service. U.S. Department of Agriculture. https://plants.usda.gov.

Ohh, S. 1981. Diseases of ginseng: environmental and host effect on disease outbreak and growth of pathogens. Korean Journal of Ginseng Science (Korea R.).

Ohh, S., Y. Yu, D. Cho, J. Lee, and Y. Kim. 1986. Effects of chemical treatments on population changes of *Ditylenchus destructor* and responses of *Panax ginseng*. Korean journal of applied entomology 25(3):169-173.

Park, K. 1975. Taxonomic study of the corn stem borer in Korea with allied species of the genus *Ostrinia* (Lep.; Pyralidae). Korean Journal of Applied Entomology 14:221-225.

Park, B.-Y., Y. H. Jeon, Z. Khan, H. Park, B.-D. Lee, D.-H. Cho, J. H. Kim, and Y. H. Kim. 2006. The root-lesion nematode, Pratylenchus subpenetrans, on ginseng (Panax ginseng) in Korea. Nematology 8(4):637-639.

Park, S. U., H.-S. Lim, K.-C. Park, Y.-H. Park, and H. Bae. 2012. Fungal endophytes from three cultivars of *Panax ginseng* Meyer cultivated in Korea. Journal of Ginseng Research 36(1):107.

PestID. 2019. Pest Identification Database (PestID). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. https://aqas.aphis.usda.gov/aqas/.

PestID. 2020. Pest Identification Database (PestID). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. https://aqas.aphis.usda.gov/aqas/.

PPQ. 2018. Plants for Planting Manual. United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (PPQ). 1366 pp.

Proctor, J. T. A., J. C. Lee, and S.-S. Lee. 1990. Ginseng production in Korea. HortScience 25(7):746-750.

Puopolo, G., S. Tomada, and I. Pertot. 2018. The impact of the omics era on the knowledge and use of *Lysobacter* species to control phytopathogenic micro-organisms. Journal of applied microbiology 124(1):15-27.

Qiao, M., W. Tian, B. Feng, Z. Yu, and Z. Peng. 2019. First Report of Soft Rot Associated with *Ilyonectria robusta* in Gastrodia elata. Plant Disease 103(10):2691-2691.

Reeleder, R. 2007. *Rhexocercosporidium panacis* sp. nov., a new anamorphic species causing rusted root of ginseng (*Panax quinquefolius*). Mycologia 99(1):91-98.

Romero, F. M., M. Marina, and F. L. Pieckenstain. 2016. Novel components of leaf bacterial communities of field-grown tomato plants and their potential for plant growth promotion and biocontrol of tomato diseases. Research in microbiology 167(3):222-233.

Seo, M.-J., H.-S. Shin, S.-H. Jo, C.-S. Gawk, H.-R. Kwon, M.-W. Park, S.-H. Kim, D.-H. Cho, Y.-M. Yu, and Y.-N. Youn. 2011. Selection of environmental-friendly control agents for controlling the comstock mealybug [*Pseudococcus comstocki* (Kuwana), Pseudococcidae, Hemiptera]. The Korean Journal of Pesticide Science 15(4):479-484.

Sessa Jusid, L. 2016. Enfermedades de cultivos frutales del Uruguay: hongos endófitos, patógenos latentes y fitopatógenos.

Shin, J.-S., D.-H. Cho, H.-S. Cho, H.-Y. Kim, and H.-S. Lee. 2008. A Report on the Damage Caused by *Phytosciara procera*, Ginseng Stem Fungus Gnat [abstract]. Journal of Ginseng Research 32(4):275-278.

Shin, S. 2013. Systematic study of Sciaridae (Diptera: Sciaroidea) in the Korean Peninsula, with discussion of larval habitats evolution Seoul National University, Department of Agricultural Biotechnology.

Takeuchi, Y., G. Fowler, and J. A. S. 2018. SAFARIS: Global Plant Hardiness Zone Development. North Carolina State University, Center for Integrated Pest Management; United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Science and Technology, Plant Epidemiology and Risk Analysis Laboratory, Raleigh, NC. 6 pp.

Tarnowski, T., and R. Ploetz. 2010. First report of *Colletotrichum boninense*, *C. capsici*, and a *Glomerella* sp. as causes of postharvest anthracnose of passion fruit in Florida. Plant Disease 94(6):786-786.

Uroz, S., S. R. Chhabra, M. Camara, P. Williams, P. Oger, and Y. Dessaux. 2005. N-Acylhomoserine lactone quorum-sensing molecules are modified and degraded by *Rhodococcus erythropolis* W2 by both amidolytic and novel oxidoreductase activities. Microbiology 151(10):3313-3322.

Wang, D., J. F. Fu, R. J. Zhou, Z. B. Li, and Y. J. Xie. 2017. Proteomics research and related functional classification of liquid sclerotial exudates of *Sclerotinia ginseng*. PeerJ 5:e3979.

6. Appendix: Pests with non-quarantine (or otherwise non-actionable) regulatory status

We found some evidence of the below listed organisms being associated with ginseng and being present in the Republic of Korea. Because these organisms are not quarantine significant for the United States (PestID, 2020; or as defined by ISPM 5, IPPC, 2019), we did not list them in Table 1 of this risk assessment. Moreover, we did not evaluate the strength of the evidence for their association with ginseng or their presence in the Republic of Korea. Because we did not evaluate the strength of the evidence, we consider the following pests to have only "potential" association with the commodity and presence in the Republic of Korea.

We list these organisms along with the references supporting their potential presence in the Republic of Korea, their presence in United States and Territories, and their potential association with ginseng. If any of the organisms listed in the table are **not** present in the United States and Territories, we also provide justification for their non-quarantine status.

Organism	In the Republic of Korea	In U.S.	Host Association	Notes
ARTHROPODS				
Acari: Acaridae				
Rhizoglyphus echinopus (Fumouze & Robin)	CABI, 2020	CABI, 2020	CABI, 2020	Non-actionable (PestID, 2020)
Rhizoglyphus robini Claparede	MAFRA, 2018	CABI, 2020	MAFRA, 2018	Non-actionable (PestID, 2020)
Diptera: Sciaridae				
Bradysia difformis Frey (syn.: *B. agrestis* Sasakawa, *B. paupera* Tuomikoski)	MAFRA, 2018		MAFRA, 2018	Genus is non-actionable (PestID, 2020)
Bradysia procera (Winnertz)	Lee et al., 2010		Lee et al., 2010; Shin et al., 2008	Genus is non-actionable (PestID, 2020). *Phytosciara procera* on ginseng (Lee et al., 2010; Shin et al., 2008) is an incorrect record of *Bradysia procera* (Shin, 2013).
Hemiptera: Flatidae				
Metcalfa pruinosa (Say)	Byeon et al., 2017	CABI, 2020	Byeon et al., 2017	Non-actionable (PestID, 2020)
Hemiptera: Pseudococcidae				
Pseudococcus comstocki (Kuwana)	Seo et al., 2011	CABI, 2020	Seo et al., 2011	Non-actionable (PestID, 2020)
Lepidoptera: Noctuidae				
Agrotis ipsilon Hufnagel	Proctor et al., 1990	CABI, 2020	Proctor et al., 1990	Non-actionable (PestID, 2020)

Peridroma saucia (Hübner)	CABI, 2020	CABI, 2020	Hausbeck, 2007	Non-actionable (PestID, 2020)
NEMATODES				
Criconemoides informis (Micoletzky) Taylor	MAFRA, 2018	GBIF, 2020	MAFRA, 2018	
Helicotylenchus dihystera (Cobb) Sher (Syn.: *Helicotylenchus crenatus*)	Chung et al., 2004	CABI, 2020	Chung et al., 2004	
Hirschmanniella oryzae (van Breda de Haan) Luc&Goodey	Chung et al., 2004	CABI, 2020	Chung et al., 2004	
Meloidogyne hapla Chitwood	Chung et al., 2004; MAFRA, 2018	CABI, 2020	Chung et al., 2004; MAFRA, 2018	
Meloidogyne incognita (Kofoid & White) Chitwood	Chung et al., 2004; MAFRA, 2018	CABI, 2020	Chung et al., 2004; MAFRA, 2018	
Pratylenchus penetrans (Cobb Filipjev & Schuurmans Stekhoven)	CABI, 2020	CABI, 2020	CABI, 2020	
Pratylenchus subpenetrans Taylor and Jenkins	Park et al., 2006	Bernhart, 2018	Park et al., 2006	
Psilenchus hilarulus De Man	Chung et al., 2004; MAFRA, 2018	MAFRA, 2018	Chung et al., 2004; MAFRA, 2018	
Tylenchorhynchus claytoni Steiner	Chung et al., 2004; MAFRA, 2018	CABI, 2020	Chung et al., 2004; MAFRA, 2018	
Xiphinema americanum Cobb	Chung et al., 2004; MAFRA, 2018	CABI, 2020	Chung et al., 2004; MAFRA, 2018	
BACTERIA				
Pectobacterium carotovorum subsp. *carotovorum* (Jones) Hauben et al. (Syn. *Erwinia carotovora* subsp. *carotovora* (Jones) Bergey)	MAFRA, 2018	CABI, 2020	MAFRA, 2018	

Pseudomonas cichorii (Swingle) Stapp	CABI, 2020	CABI, 2020	CABI, 2020
Pseudomonas fluorescens (Trevisan) Migula	MAFRA, 2018	CABI, 2020	MAFRA, 2018
Pseudomonas marginalis (Brown) Stevens	Lee et al., 2011	CABI, 2020	Lee et al., 2011
Pseudomonas syringae pv. syringae van Hall	CABI, 2020	CABI, 2020	CABI, 2020
Serratia liquefaciens (Grimes and Hennerty) Bascomb et al.	Dong et al., 2004	Dong et al., 2004	Kilonzo-Nthenge et al., 2008
FUNGI			
Alternaria panax Whetzel	CABI, 2020	CABI, 2020	CABI, 2020
Berkeleyomyces basicola (Berk. & Broome) W.J. Nel, Z.W. de Beer, T.A. Duong & M.J. Wingf. Syn.: *Chalara elegans* Nag Raj & W.B. Kendr., *Thielaviopsis basicola* (Berk. & Broome) Ferraris	Farr and Rossman, 2019	Farr and Rossman, 2019	Farr and Rossman, 2019
Botrytis cinerea Pers. : Fr. 1794 Syn.: *Botrytis fuckeliana* (de Bary) Whetzel, *Botryotinia fuckeliana* (de Bary) Whetzel	Farh et al., 2018	Farr and Rossman, 2019	Farr and Rossman, 2019
Colletotrichum dematium (Pers. : Fr.) Grove	CABI, 2020	CABI, 2020	CABI, 2020
Colletotrichum gloeosporioides (Penz.) Sacc.	Cho and Shin, 2004	CABI, 2020	Farr and Rossman, 2019
Colletotrichum truncatum (Schwein.) Andrus & W.D. Moore	CABI, 2020	CABI, 2020	CABI, 2020
Cylindrocarpon destructans (Zins) Scholten	Farr and Rossman, 2019	Farr and Rossman, 2019	Farh et al., 2018
Fusarium acuminatum Ellis & Everh.	Lu et al., 2019	Farr and Rossman, 2019	Lu et al., 2019
Fusarium avenaceum (Fr.: Fr.) Sacc. Teleomorph: *Gibberella avenacea* R.J. Cook	Lu et al., 2019	Farr and Rossman, 2019	Lu et al., 2019

Fusarium solani (Mart.) Sacc. Syn.: *Fusarium martii var. minus*	Farr and Rossman, 2019	Farr and Rossman, 2019	Farr and Rossman, 2019	
Fusarium sporotrichioides Sherb.	Guan et al.,	Farr and Rossman, 2019	Farr and Rossman, 2019	
Globisporangium debaryanum (R. Hesse) Uzuhashi, Tojo & Kakish.	Farr and Rossman, 2019	Farr and Rossman, 2019	Farr and Rossman, 2019	
Globisporangium irregulare (Buisman) Uzuhashi, Tojo & Kakish. (Syn.: *Pythium irregulare*)	Farr and Rossman, 2019	Farr and Rossman, 2019	Farr and Rossman, 2019	
Globisporangium ultimum (Trow) Uzuhashi, Tojo & Kakish; Syn.: *Pythium ultimum* Trow	Farr and Rossman, 2019	Farr and Rossman, 2019	Farr and Rossman, 2019	
Haplotrichum curtisii (Berk.) Hol.-Jech.	Farr and Rossman, 2019	Farr and Rossman, 2019	Farr and Rossman, 2019	
Neocosmospora haematococca (Berk. & Broome) Samuels, Nalim & Geiser (Syn.: *Haematonectria haematococca*)	CABI, 2020	CABI, 2020	CABI, 2020	
Paraphoma radicina (McAlpine) Morgan-Jones & J.F. White (Syn.: *Phoma radicina*)	Park et al., 2012	Farr and Rossman, 2019	Park et al., 2012	
Phytophthora cactorum (Lebert & Cohn) J. Schröt.	CABI, 2020	CABI, 2020	CABI, 2020	
Rhizoctonia solani J.G. Kühn	Farr and Rossman, 2019	Farr and Rossman, 2019	Farr and Rossman, 2019	
Sclerotinia minor Jagger	Proctor et al., 1990	Farr and Rossman, 2019	Proctor et al., 1990	
Sclerotinia sclerotiorum (Lib.) de Bary	CABI, 2020	CABI, 2020	CABI, 2020	
VIRUSES				
Potyvirus Watermelon mosaic virus	CABI, 2020	CABI, 2020	CABI, 2020	