USDA Animal and Plant Health Inspection Service
U.S. DEPARTMENT OF AGRICULTURE

# Importation of lemon, grapefruit, mandarin, and sweet orange (*Citrus limon*, *C. paradisi*, *C. reticulata*, and *C. sinensis*) fruit from Botswana into the United States for consumption

## A Qualitative, Pathway Initiated Pest Risk Assessment

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## Executive Summary

The purpose of this report is to assess the pest risks associated with importing commercially produced fruit of lemon, grapefruit, mandarin, and sweet orange (*Citrus limon*, *C. paradisi*, *C. reticulata*, and *C. sinensis*) (Rutaceae) from Botswana into the United States for consumption.

Based on the market access request submitted by Botswana, we considered the pathway to include the following processes and conditions: culling of visibly and conspicuously damaged fruit. The pest risk ratings depend on the application of all conditions of the pathway as described in this document; fruit produced under different conditions were not evaluated and may pose a different pest risk.

We used scientific literature, port-of-entry pest interception data, and information from the government of Botswana to develop a list of pests with quarantine significance for the United States. These are pests that occur in Botswana 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 have met the threshold for unacceptable consequences of introduction and can follow the commodity import pathway.

| **Pest type** | **Taxonomy** | **Scientific name** | **Likelihood of Introduction** | ***Citrus* species affected**[1] |
|---|---|---|---|---|
| INSECT | Diptera: Tephritidae | *Ceratitis cosyra* (Walker) | High | CL, CP, CR, CS |
| INSECT | Diptera: Tephritidae | *Ceratitis rosa* Karsch | High | CP, CR, CS |
| INSECT | Diptera: Tephritidae | *Dacus ciliatus* Loew | Medium | CR, CS |
| INSECT | Lepidoptera: Tortricidae | *Thaumatotibia leucotreta* (Meyrick) | Medium | CP, CR, CS |

The following organisms are likely to follow the pathway but were not assessed in this document because they have already been determined to pose an unacceptable risk to the United States. Domestic regulations are in place for these pests:

[1] CL is *Citrus limon*, CP is *C. paradisi*, CR is *C. reticulata*, and CS is *C. sinensis*.

| Pest type | Taxonomy | Scientific name | Regulations | *Citrus* species affected |
|---|---|---|---|---|
| INSECT | Diptera: Tephritidae | *Bactrocera dorsalis* (Hendel) | 7 CFR § 301.32, 2023 | CL, CP, CR, CS |
| INSECT | Diptera: Tephritidae | *Ceratitis capitata* (Wiedemann) | 7 CFR § 301.32, 2023 | CL, CP, CR, CS |
| FUNGI | Botryosphaeriales: Phyllostictaceae | *Phyllosticta citricarpa* (McAlpine) Aa[2]; syn. *Guignardia citricarpa* Kiely | Federal Order DA-2012-09 (USDA-APHIS, 2012) | CL, CP, CR, CS |

The detailed examination and choice of appropriate phytosanitary measures to mitigate pest risk are addressed in a separate document.

[2] PPQ previously assessed the risk of citrus fruit as a pathway for *P. citricarpa* and determined it to have a low pest risk potential on fruit that has not gone through any post-harvest processing (USDA-APHIS, 2010).

# Table of Contents

# 1. Introduction

## 1.1. Background

The purpose of this report is to present PPQ's assessment of the pest risk associated with the importation of commercially produced fresh fruit of lemon, grapefruit, mandarin, and sweet orange (*Citrus limon* (L.) Burm. f., *C. paradisi* Macfad., *C. reticulata* Blanco, and *C. sinensis* (L.) Osbeck) from Botswana (referred to as the export area) into the United States[3] (referred to as the pest risk analysis or PRA area) for consumption.

This is a qualitative risk assessment. The likelihood of pest introduction is expressed as a qualitative rating rather than using 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, 2021). The use of biological and phytosanitary terms is consistent with ISPM No. 5, "Glossary of Phytosanitary Terms" (IPPC, 2022).

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 Subpart L – Fruits and Vegetables (7 CFR §319.56, 2023) and as described in the Agricultural Commodity Import Requirements. Under this regulation, the entry of fruit of lemon, grapefruit, mandarin, and sweet orange from Botswana into the PRA area is not authorized. This commodity risk assessment was initiated in response to a request by the government of Botswana to change the federal regulation to allow entry (BMADFS, 2022).

## 1.3. Potential weediness of the commodity

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

A weed risk analysis is not required when (a) the commodity is already enterable into the PRA area from other countries, (b) the commodity plant species is widely established or cultivated in the PRA area, or (c) the imported plant part(s) cannot easily propagate on its own or be propagated. We determined that the weed risk of lemon, grapefruit, mandarin, and sweet orange does not need to be analyzed because these commodities are already enterable from other countries (ACIR, 2024).

## 1.4. Description of the pathway

A pathway is "any means that allows the entry or spread of a pest" (IPPC, 2022). In the context of this document, the pathway is the commodity to be imported. The following description

[3]The *United States* includes all states, the District of Columbia, Guam, the Northern Mariana Islands, Puerto Rico, the U.S. Virgin Islands, and any other territory or possession of the United States.

includes those conditions and processes the commodity undergoes from production through importation and distribution that may have an impact on pest risk and therefore were considered in our assessment. Commodities produced under different conditions were not considered.

1.4.1. Description of the commodity

The specific pathway of concern is the importation of fresh fruit of lemon, grapefruit, mandarin, and sweet orange for consumption.

1.4.2. Summary of the production, harvest, post-harvest, shipping, and storage conditions considered

No production or harvesting procedures, post-harvest procedures, or shipping and storage conditions were considered except culling of visibly and conspicuously damaged fruit.

## 2. Pest List and Pest Categorization

The pest list is a compilation of plant pests of quarantine significance to the United States. This list includes pests that are present in Botswana on any host and are known to be associated with *Citrus limon*, *C. paradisi*, *C. reticulata*, and/or *C. sinensis* anywhere in the world. Pests are considered quarantine significant if they (a) are not present in the PRA area, (b) are actionable at U.S. ports of entry, (c) are regulated non-quarantine pests, (d) are under federal official control, or (e) require evaluation for regulatory action. Consistent with ISPM No. 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

We developed the pest list based on scientific literature, port-of-entry pest interception data, and information provided by the government of Botswana. We listed the pests that are of quarantine significance to the PRA area in Table 1. For each pest, we provided evidence for the pest's presence in Botswana and its association with grapefruit, lemon, sweet orange, and/or mandarin (*Citrus limon*, *C. paradisi*, *C. reticulata*, and/or *C. sinensis*). We indicated the plant parts with which the pest is generally associated and, if applicable, provided information about the pest's distribution in the United States. Pests that are likely to remain associated with the harvested commodity in a viable form are indicated by bolded text and are listed separately in Table 2.

**Table 1**. List of quarantine pests associated with *Citrus limon* (CL), *C. paradisi* (CP), *C. reticulata* (CR), and/or *C. sinensis* (CS) anywhere in the world and present in Botswana on any host

| Pest name | Presence in Botswana | Host association | Plant part(s) [4] | Considered further? [5] |
|---|---|---|---|---|
| **INSECT**<br>**Diptera: Tephritidae**<br>***Bactrocera dorsalis* (Hendel); syn. *Bactrocera invadens* Drew, Tsuruta & White** | **BMADFS, 2022** | **CL (Ndiaye et al., 2012; Vargas et al., 2010)**<br><br>**CP (Ndiaye et al., 2012; Vargas et al., 2010)**<br><br>**CR (Kambura et al., 2018; Vargas et al., 2010)**<br><br>**CS (Kambura et al., 2018; Ndiaye et al., 2012; Onah et al., 2015)** | **Fruit (BMADFS, 2022; Kambura et al., 2018; Onah et al., 2015; Vargas et al., 2010)** | **Yes**<br><br>**This is a domestic quarantine species and is regulated by the U.S. Code of Federal Regulations (7 CFR § 301.32, 2023).**<br><br>**Present in Hawaii (Vargas et al., 2010).** |

[4] The plant part(s) 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.

[5] "Yes" indicates simply that the pest has a reasonable likelihood of being associated with the harvested commodity; 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 Botswana | Host association | Plant part(s) [4] | Considered further? [5] |
|---|---|---|---|---|
| **INSECT**<br>**Diptera: Tephritidae**<br>***Ceratitis capitata***<br>**(Wiedemann)** | **BMADFS, 2022** | **CL (De Meyer et al., 2002)**<br><br>**CP (Ndiaye et al., 2012)**<br><br>**CR (De Meyer et al., 2002; Duyck et al., 2008)**<br><br>**CS (De Meyer et al., 2002)** | **Fruit (BMADFS, 2022)** | **Yes**<br><br>**This is a domestic quarantine species and is regulated by the U.S. Code of Federal Regulations (7 CFR § 301.32, 2023).**<br><br>**Present in Hawaii (Follett et al., 2009; Gasperi et al., 2002).** |
| **INSECT**<br>**Diptera: Tephritidae**<br>***Ceratitis cosyra***<br>**(Walker)** | **EPPO, 2024** | **CL (Zida et al., 2020)**<br><br>**CP (Ali et al., 2014)**<br><br>**CR (Kambura et al., 2018; Mwatawala et al., 2009)**<br><br>**CS (Kambura et al., 2018)** | **Fruit (Kambura et al., 2018; Zida et al., 2020)** | **Yes** |

| Pest name | Presence in Botswana | Host association | Plant part(s) [4] | Considered further? [5] |
|---|---|---|---|---|
| **INSECT Diptera: Tephritidae *Ceratitis rosa* Karsch** | **BMADFS, 2022** | **CP (De Meyer et al., 2002; Duyck et al., 2008)**<br><br>**CR (Copeland et al., 2006; De Meyer et al., 2002; Duyck et al., 2008)**<br><br>**CS (De Meyer et al., 2002)** | **Fruit (BMADFS, 2022)** | **Yes** |
| **INSECT Diptera: Tephritidae *Dacus ciliatus* Loew** | **EPPO, 2021** | **CR, CS (Kambura et al., 2018)** | **Fruit (Kambura et al., 2018)** | **Yes** |
| INSECT Hemiptera: Aphididae *Toxoptera citricidus* (Kirkaldy) | BMADFS, 2022 | CR, CS (Michaud and Alvarez, 2000) | Leaves (BMADFS, 2022), twigs (Michaud and Alvarez, 2000) | No |
| INSECT Hemiptera: Coccidae *Ceroplastes destructor* Newstead; syn. *Gascardia destructor* (Newstead) | BMADFS, 2022 | CR, CS (García-Morales et al., 2016) | Stems (CABI, 2024) | No |
| INSECT Hemiptera: Monophlebidae *Icerya seychellarum* (Westwood) | García-Morales et al., 2016 | CL, CR, CS (García-Morales et al., 2016) | Leaves (Hill, 1983; Umeya and Okada, 2003), young branches (Umeya and Okada, 2003) | No |
| INSECT Hemiptera: Triozidae *Trioza erytreae* (Del Guercio) | BMADFS, 2022 | CL, CP, CR, CS (Siverio et al., 2017) | Leaves, shoots (Siverio et al., 2017) | No |

| Pest name | Presence in Botswana | Host association | Plant part(s) [4] | Considered further? [5] |
|---|---|---|---|---|
| **INSECT**<br>**Lepidoptera: Noctuidae**<br>***Helicoverpa armigera*** **(Hübner); syn.** *Heliothis armigera* Hübner | BMADFS, 2022; Daoust and Roome, 1974 | CS (Siyoko, 2011) | Buds, flowers, leaves (Siyoko, 2011) fruit, (BMADFS, 2022; Siyoko, 2011) | No<br><br>See notes in Section 2.2. |
| **INSECT**<br>**Lepidoptera: Tortricidae**<br>***Thaumatotibia leucotreta*** **(Meyrick); syn.** ***Cryptophlebia leucotreta*** **Meyrick** | **BMADFS, 2022** | **CP (van de Vossenberg et al., 2023)**<br><br>**CR (Trematerra, 2023; van de Vossenberg et al., 2023)**<br><br>**CS (Catling and Aschenborn, 1978; van de Vossenberg et al., 2023)** | **Branches, leaves (Trematerra, 2023), fruit (Catling and Aschenborn, 1978; Trematerra, 2023)** | **Yes** |
| INSECT<br>Thysanoptera: Thripidae<br>*Scirtothrips aurantii* Faure | BMADFS, 2022 | CL, CS (Rafter and Walter, 2012) | Fruit, leaves (Peña et al., 2002) | No<br><br>See notes in Section 2.2. |
| MITE<br>Trombidiformes: Eriophyidae<br>*Calacarus citrifolii* Keifer | BMADFS, 2022 | CL (Kotze et al., 1987) | Leaves of seedlings (Kotze et al., 1987) | No |

| Pest name | Presence in Botswana | Host association | Plant part(s) [4] | Considered further? [5] |
|---|---|---|---|---|
| MOLLUSK<br>Stylommatophora: Helicidae<br>*Theba pisana* (O.F. Müller) | EPPO, 2024 | CS (Mohammed, 2015) | Foliar buds, young leaves, fruit surfaces (Ali and Robinson, 2020) | No<br><br>The white garden snail is an indiscriminate surface feeding pest, rasping off the tissue from stems, branches, twigs, leaves, and fruits (Hashem and El-Halawany, 1996); culling would remove it from the pathway.<br><br>Present in California (Field Museum, 2022) |
| FUNGI<br>*Diplodia aurantii* Catt. and Garov. | BMADFS, 2022 | CL, CP, CR, CS (Farr and Rossman, 2024) | Stems, twigs (BMADFS, 2022; Balmas et al., 2005) | No<br><br>This pest is not associated with the plant part being imported. |
| **FUNGI**<br>***Phyllosticta citricarpa* (McAlpine) Aa; syn. *Guignardia citricarpa* Kiely** | **Mawere et al., 2024; BMADFS, 2022** | **CL, CP, CR (Schirmacher et al., 2019)**<br><br>**CS (Mawere et al., 2024; Schirmacher et al., 2019)** | **Fruit, leaves (Schirmacher et al., 2019; Timmer et al., 2000)** | **Yes**<br><br>***Phyllosticta citricarpa* was determined to have a low pest risk potential on citrus fruit that has not gone through any post-harvest processing (USDA-APHIS, 2010).**<br><br>**This is a domestic quarantine species and is regulated by Federal Order DA-2012-09 (USDA-APHIS, 2012).**<br><br>**Present in Florida (USDA-APHIS, 2024).** |

### 2.2. Notes on pests identified in the pest list

***Helicoverpa armigera* (Hübner) (INSECT: Lepidoptera: Noctuidae)**
Old world bollworm larvae feed on young, developing fruit, which they may partially or completely destroy (Butani, 1979; Siyoko, 2011; Smith et al., 1997). Damaged fruit falls off the tree (Butani, 1979; Smith et al., 1997) where it would not be harvested. Feeding on mature oranges only occurs externally; only the outer part of the fruit skin (the flavedo) is consumed while the inner part of the skin (the albedo) is not penetrated (Siyoko, 2011). Harvesters will likely remove this conspicuous, externally feeding larvae from the fruit. For these reasons, we consider the likelihood of *H. armigera* following the pathway to be negligible.

***Scirtothrips aurantii* Faure (INSECT: Thysanoptera: Thripidae)**
The South African citrus thrips lays eggs on young citrus fruit (Peña et al., 2002). Generally, the youngest fruits are affected making it less likely that thrips will remain on mature fruit (CABI, 2024). Rarely, a thrips may pupate under the calyx of citrus fruit (Peña et al., 2002). As tiny insects with poor flight capabilities (Lewis, 1991), thrips are not likely to move long distances unaided. They can, however, move several kilometers via wind dispersal (Fernandes and de Sena Fernandes, 2015; Lewis, 1991), but it is not likely citrus fruits will be placed in windy, outdoor conditions. Because the youngest fruits are affected, it is less likely that thrips will remain on mature fruit (CABI, 2024) and thrips numbers will not be high enough to facilitate finding a mate. Low numbers will also reduce the probability of successful escape into the environment. Therefore, we believe this thrips has a negligible risk of following the pathway or establishing.

### 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 grapefruit, lemon, sweet orange, and/or mandarin fruit and are present in the export area; however, they are not of quarantine significance for the PRA area (see Appendix).

Armored scales (Hemiptera: Diaspididae): These insects are highly unlikely to establish via the fruits or vegetables for consumption pathway due to their very limited ability to disperse to new host plants (Miller et al., 1985; PERAL, 2007). Also, diaspidids on fruits and vegetables for consumption are considered non-actionable at U.S. ports of entry (NIS, 2008). For these reasons, armored scales are included in the Appendix rather than Table 1, even if they are not present in the PRA area.

2.3.2. Quarantine pests considered but not included on the pest list

*Candidatus* Liberibacter africanus (Rhizobiales: Phyllobacteriaceae): This species is present in South Africa (Crous et al., 2000), but we did not find evidence of its presence in Botswana. Fruits are not considered a pathway for this species (7 CFR § 301.76, 2012).

### 2.4. Pests selected for further analysis or already regulated

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

**Table 2.** Pests selected for further analysis

| Pest type | Taxonomy | Scientific name | *Citrus* species affected |
|---|---|---|---|
| INSECT | Diptera: Tephritidae | *Ceratitis cosyra* (Walker) | CL, CP, CR, CS |
| INSECT | Diptera: Tephritidae | *Ceratitis rosa* Karsch | CP, CR, CS |
| INSECT | Diptera: Tephritidae | *Dacus ciliatus* Loew | CR, CS |
| INSECT | Lepidoptera: Tortricidae | *Thaumatotibia leucotreta* (Meyrick) | CP, CR, CS |

The following pests can follow the commodity pathway. However, they were not assessed because they were previously determined to pose an unacceptable risk to the PRA area and domestic regulations are in place. These pests are candidates for risk mitigation.

| Pest type | Taxonomy | Scientific name | Regulations | *Citrus* species affected |
|---|---|---|---|---|
| INSECT | Diptera: Tephritidae | *Bactrocera dorsalis* (Hendel) | 7 CFR § 301.32, 2023 | CL, CP, CR, CS |
| INSECT | Diptera: Tephritidae | *Ceratitis capitata* (Wiedemann) | 7 CFR § 301.32, 2023 | CL, CP, CR, CS |
| FUNGI | Botryosphaeriales: Phyllostictaceae | *Phyllosticta citricarpa* (McAlpine) Aa; syn. *Guignardia citricarpa* Kiely | Federal Order DA-2012-09 (USDA-APHIS, 2012) | CL, CP, CR, CS |

## 3. Assessing Pest Risk Potential

### 3.1. Introduction

Risk is described by the likelihood of introduction, the potential consequences, and the associated uncertainty. For each pest, we determined if an endangered area exists within the United States. The endangered area is defined as the portion of the PRA area where ecological factors favor the pest's establishment and where the pest's presence will likely result in economically important impacts. If a pest causes an unacceptable impact, that means it could adversely affect agricultural production by causing a yield loss of 10 percent or greater, by increasing U.S. production costs, by impacting an environmentally important host, or by impacting international trade. After the endangered area was defined, we assessed the pest's likelihood of introduction into that area via the imported commodity.

The likelihood of introduction is based on the potential entry and establishment of a pest. We qualitatively assessed this using the ratings: Low, Medium, and High. The elements comprising the likelihood of introduction are interdependent; therefore, the model is multiplicative rather than additive. We defined the ratings as follows:

**High**: This outcome is highly likely to occur because the events required occur frequently.
**Medium**: This outcome can occur; however, the combination of required events occurs only occasionally.
**Low**: This outcome is less likely because the exact combination of required events seldom occur or rarely align properly in time and space.

We addressed uncertainty associated with each element as follows:

**Negligible:** Additional or more reliable evidence is very unlikely to change the rating.
**Low:** Additional or more reliable evidence probably will not change the rating.
**Moderate:** Additional or more reliable evidence may or may not change the rating.
**High:** Reliable evidence is not available.

### 3.2. Assessment

3.2.1. *Ceratitis cosyra* (Diptera: Tephritidae)

The mango fruit fly is distributed across sub-Saharan Africa (CABI, 2024; Steck, 2015). Its primary host in Africa is native plant *Sclerocarya birrea* (marula), but the mango fruit fly is an important pest of mangoes (CABI, 2024; Steck, 2015). Fruits can be heavily infested; 50 larvae may be found per fruit (Steck, 2015). Two generations per year have been suggested (Hill, 1983).

**The endangered area for *Ceratitis cosyra* within the United States**

*Climatic suitability:* *Ceratitis cosyra* is present in **Africa:** Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Congo, Cote d'Ivoire, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Madagascar, Malawi, Mali, Mozambique, Namibia, Nigeria, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, and Zimbabwe (EPPO, 2024). These areas encompass Plant Hardiness Zones 8 to 13 (Takeuchi et al., 2018). In the United States, these areas include the southern continental United States, the eastern and western coasts of the continental United States, Hawaii, Puerto Rico, and other U.S. territories.

*Hosts in United States:* Host plants in the United States include **Anacardiaceae:** *Anacardium occidentale* (cashew), *Mangifera indica* (mango), *Spondias mombin* (mombin); **Annonaceae:** *Annona cherimola* (cherimoya), *Annona muricata* (soursop), *Annona reticulata* (custard apple), *Rollinia mucosa* (wild sugar apple); **Apocynaceae:** *Thevetia peruviana* (luckynut); **Combretaceae:** *Terminalia catappa* (tropical almond); **Flacourtiaceae:** *Flacourtia indica* (governor's plum); **Goodeniaceae:** *Scaevola plumieri* (gullfeed); **Lauraceae:** *Persea americana* (avocado); **Myrtaceae:** *Eugenia uniflora* (Surinam cherry), *Psidium guajava* (guava), *Syzygium cumini* (Java plum); **Olacaceae:** *Ximenia americana* (tallow wood); **Oxalidaceae:** *Averrhoa carambola* (carambola); **Rhamnaceae:** *Ziziphus mauritiana* (Indian jujube); **Rosaceae:** *Eriobotrya japonica* (loquat), *Malus pumila* (paradise apple); **Rutaceae:** *Citrus limon* (lemon), *C. paradisi* (grapefruit), *C. reticulata* (mandarin), *C. sinensis* (sweet orange), *Fortunella margarita* (oval kumquat); **Sapindaceae:** *Blighia sapida* (akee); and **Solanaceae:** *Capsicum annuum* (pepper), *Solanum lycopersicum* (tomato), *Solanum melongena* (eggplant) (Badii et al., 2015; Copeland et al., 2006; Kambura et al., 2018; Mwatawala et al., 2009; NRCS, 2024).

*Economically important hosts*[6]*:* Apple, avocado, cherimoya, eggplant, grapefruit, guava, lemon, mandarin, mango, pepper, soursop, sweet orange, and tomato (NASS, 2019, 2020).

*Potential consequences on economically important hosts at risk:* This pest is likely to cause unacceptable consequences because larvae of the mango fruit fly feed within fruit, leaving them rotten and inedible (Kambura et al., 2018). Fifty larvae may be found per fruit (Steck, 2015).

***Endangered area:*** Areas in Plant Hardiness Zones 8 to 13 where host plants occur.

[6] As defined by ISPM No. 5, potential economic importance applies to crops, the environment (ecosystems, habitats, or species), and to other specified values such as tourism, recreation and aesthetics (IPPC, 2022).

**The likelihood of entry of *Ceratitis cosyra* into the endangered area via lemon, grapefruit, mandarin, and sweet orange fruit imported from Botswana**

| Risk Element | Risk Rating | Uncertainty Rating | Evidence for rating (and other notes as necessary) |
|---|---|---|---|
| Pest prevalence on the harvested commodity | High | Negligible | *Ceratitis cosyra* infests the fruit of lemon, grapefruit, mandarin, and sweet orange (Kambura et al., 2018; Ali et al., 2014; Mwatawala et al., 2009; Zida et al., 2020). In Kenya, one study found that *Ceratitis cosyra* infests *Citrus reticulata* at 2.7 flies/kg of fruit and *C. sinensis* at 2.3 flies/kg of fruit (Kambura et al., 2018). In Burkina Faso, another study found that *C. cosyra* infests *C. limon* at 3.10 flies/kg of fruit and *C. sinensis* at 0.95 flies/kg (Zida et al., 2020). In Tanzania, a study found that the fruit fly infests citrus at 0.07 flies/kg of fruit (Mwatawala et al., 2009). |
| Likelihood of surviving post-harvest processing before shipment | High | Moderate | No post-harvest processes were considered other than culling of visibly and conspicuously damaged fruit. Fruit fly eggs are inserted within the fruit tissue and larvae are internal feeders. Therefore, it is not always possible to recognize fruit fly-infested fruit (White and Elson-Harris, 1992). However, another source states that there are signs of oviposition punctures, such as necrosis (CABI, 2024). Therefore, we maintain a risk rating of High, but with Moderate uncertainty. |
| Likelihood of surviving transport and storage conditions of the consignment | High | Negligible | No transport or storage conditions were considered; therefore, we maintain a risk rating of High. |
| **Overall Likelihood of Entry** | High | n/a | n/a |

**The likelihood of establishment of *Ceratitis cosyra* into the endangered area via lemon, grapefruit, mandarin, and sweet orange fruit imported from Botswana**

| Risk Element | Risk Rating | Uncertainty Rating | Evidence for rating (and other notes as necessary) |
|---|---|---|---|
| Likelihood of Establishment | High | Moderate | Many host plants of *Ceratitis cosyra* are abundant in the territories of the United States (NRCS, 2024). Several host plants are widespread across the continental United States, such as *Malus pumila* (paradise apple), *Capsicum annuum* (pepper), and *Solanum lycopersicum* (tomato) (NRCS, 2024). However, fruits may only be available seasonally, contributing to our uncertainty rating of Moderate. Adults are highly mobile, using flight as a major means of movement (CABI, 2024). Fruits can be heavily infested; up to 115 larvae have been reported from a single fruit in Kenya (Malio, 1979). In Kenya, up to 25% of fallen mango fruits can contain *C. cosyra* larvae (Malio, 1979). The mean number of larvae per infested fruit from four different collection days ranged from 43 to 53 larvae per fruit (Malio, 1979). These high numbers could enable finding a mate, successfully finding a host, and reproducing. Therefore, we chose a risk rating of High. |
| **Overall Likelihood of Establishment** | High | n/a | n/a |

**The likelihood of introduction (combined likelihoods of entry and establishment) of *Ceratitis cosyra* into the endangered area via lemon, grapefruit, mandarin, and sweet orange fruit imported from Botswana is High.**

3.2.2. *Ceratitis rosa* (Diptera: Tephritidae)

The fruit fly species *Ceratitis rosa* Karsch sensu lato was recently split into two different species: *Ceratitis rosa* Karsch sensu stricto and *Ceratitis quilicii* De Meyer, Mwatawala & Virgilio (De Meyer et al., 2016). Therefore, literature written prior to 2016 may be referring to either of these species when using the species name *Ceratitis rosa*. *Ceratitis rosa* is a significant pest of avocado (de Villiers, 2001), lychee (Grové et al., 2004), citrus (Smith and J.E. Peña, 2002), and guava (Gould and Raga, 2002). Females lay eggs on fruits, causing soft dark spots which become infected with secondary infections (Hill, 1983). As larvae feed within the fruit, the fruit pulp softens and rots (Hill, 1983). Infested fruits often fall prematurely (Hill, 1983). In the laboratory, the fecundity of *C. rosa* fed an artificial diet averaged 520 eggs per female (Monty, 1973). Depending on climatic conditions, 6 to 12 generations may occur per year (Hill, 1983).

**The endangered area for *Ceratitis rosa* within the United States**

*Climatic suitability:* *Ceratitis rosa* is present in **Africa:** Burkina Faso, Kenya, Malawi, Mozambique, South Africa, and Tanzania (EPPO, 2024). These areas encompass Plant Hardiness Zones 9 to 13 (Takeuchi et al., 2018). In the United States, these Plant Hardiness Zones encompass the southern portions and east and west coasts of the continental United States.

*Hosts in United States:* **Anacardiaceae:** *Anacardium occidentale* (cashew), *Mangifera indica* (mango); **Annonaceae:** *Annona cherimola* (cherimoya), *Annona muricata* (soursop), *Annona reticulata* (custard apple), *Annona squamosa* (sugar apple), *Cananga odorata* (ilang-ilang); **Apocynaceae:** *Carissa macrocarpa* (amatungulu); **Cactaceae:** *Opuntia ficus-indica* (Barbary fig); **Caricaceae:** *Carica papaya* (papaya); **Clusiaceae:** *Garcinia mangostana* (mangosteen); **Combretaceae:** *Terminalia catappa* (tropical almond); **Euphorbiaceae:** *Phyllanthus acidus* (Tahitian gooseberry tree); **Fabaceae:** *Inga laurina* (sacky sac bean); **Flacourtiaceae:** *Dovyalis hebecarpa* (Ceylon gooseberry), *Flacourtia indica* (governor's plum); **Lauraceae:** *Persea americana* (avocado); **Moraceae:** *Ficus carica* (edible fig); **Myrtaceae:** *Eugenia uniflora* (Surinam cherry), *Psidium guajava* (guava), *Syzygium cumini* (Java plum), *Syzygium jambos* (Malabar plum), *Syzygium malaccense* (Malaysian apple); **Oxalidaceae:** *Averrhoa carambola* (carambola); **Polygonaceae:** *Coccoloba uvifera* (seagrape); **Rhamnaceae:** *Ziziphus mauritiana* (Indian jujube); **Rosaceae:** *Cydonia oblonga* (quince), *Eriobotrya japonica* (loquat), *Malus pumila* (paradise apple), *Prunus armeniaca* (apricot), *Prunus domestica* (European plum), *Prunus persica* (peach), *Pyrus communis* (common pear); **Rubiaceae:** *Coffea arabica* (Arabian coffee); **Rutaceae:** *Citrus aurantium* (sour orange), *C. reticulata* (tangerine), *C. paradisi* (grapefruit), *C. sinensis* (sweet orange); **Sapindaceae:** *Dimocarpus longan* (longan); **Sapotaceae:** *Chrysophyllum cainito* (star apple), *Manilkara zapota* (sapodilla); **Solanaceae:** *Capsicum annuum* (pepper); and **Sterculiaceae:** *Theobroma cacao* (cacao) (Badii et al., 2015; Copeland et al., 2006; De Meyer et al., 2002). These hosts all occur in the PRA area (NRCS, 2024).

*Economically important hosts*[7]*:* Apricot, avocado, coffee, grapefruit, guava, mango, papaya, peach, pear, pepper, plum, sweet orange, and tangerine (NASS, 2019).

*Potential consequences on economically important hosts at risk:* This pest is likely to cause unacceptable consequences because fruit is damaged through oviposition of eggs into the fruit's skin. Hatching larva tunnel through the fruit pulp which softens and rots (Hill, 1983). Infested fruit become infected by secondary infections and may fall prematurely (Hill, 1983). Heavy losses can occur to commercial fruit crops (CABI, 2024).

***Endangered area:*** The endangered area includes areas in Plant Hardiness Zones 9 to 13 where host plants are present.

[7] As defined by ISPM No. 5, potential economic importance applies to crops, the environment (ecosystems, habitats, or species), and to other specified values such as tourism, recreation and aesthetics (IPPC, 2022).

**The likelihood of entry of *Ceratitis rosa* into the endangered area via grapefruit, mandarin, and sweet orange fruit imported from Botswana**

| Risk Element | Risk Rating | Uncertainty Rating | Evidence for rating (and other notes as necessary) |
|---|---|---|---|
| Pest prevalence on the harvested commodity | High | Negligible | *Ceratitis rosa* infests the fruit of grapefruit, mandarin, and sweet orange (Copeland et al., 2006; De Meyer et al., 2002; Duyck et al., 2008). Hundreds of individuals were reared from field-collected citrus fruit (Duyck et al., 2008). Therefore, we chose a risk rating of High. |
| Likelihood of surviving post-harvest processing before shipment | High | Moderate | No post-harvest processes were considered other than culling of visibly and conspicuously damaged fruit. Fruit fly eggs are inserted within the fruit tissue and larvae are internal feeders. Therefore, it is not always possible to recognize fruit fly-infested fruit (White and Elson-Harris, 1992). However, source states that some attacked fruits may show signs of oviposition and very sweet fruits may exude a sugary exudate (CABI, 2024). Therefore, we maintain a risk rating of High, but with Moderate uncertainty, due to disparate information on whether infested fruits display conspicuous oviposition marks. |
| Likelihood of surviving transport and storage conditions of the consignment | High | Negligible | No transport or storage conditions were considered; therefore, we maintain a risk rating of High. |
| **Overall Likelihood of Entry** | High | n/a | n/a |

**The likelihood of establishment of *Ceratitis rosa* into the endangered area via grapefruit, mandarin, and sweet orange fruit imported from Botswana**

| Risk Element | Risk Rating | Uncertainty Rating | Evidence for rating (and other notes as necessary) |
|---|---|---|---|
| Likelihood of Establishment | High | Moderate | Eggs are deposited in batches of 10 to 20 per fruit; pupation occurs in the soil (Orian and Moutia, 1960). Thus, adult males and females would emerge near each other, facilitating mate-finding and copulation. Females may disperse over considerable distances in search of hosts (Carnegie, 1962), although another source states that adults tend to remain in their area of emergence, usually within a few hundred meters (CABI, 2024), increasing our uncertainty to Medium. They also may live as long as six months (Annecke and Moran, 1982) which increases the likelihood of establishment. Many host plants of *Ceratitis rosa* are abundant in the territories of the United States (NRCS, 2024).<br><br>Several host plants are widespread across the continental United States in Plant Hardiness Zones 9 to 13, such as *Capsicum annuum* (pepper), *Ficus carica* (edible fig), *Malus pumila* (paradise apple), *Opuntia ficus-indica* (Barbary fig), *Prunus domestica* (European plum), *Prunus persica* (peach), and *Pyrus communis* (common pear) (NRCS, 2024), contributing to our risk rating of High. However, fruits may only be available seasonally, contributing to our uncertainty rating of Moderate. |
| **Overall Likelihood of Establishment** | High | n/a | n/a |

**The likelihood of introduction (combined likelihoods of entry and establishment) of *Ceratitis rosa* into the endangered area via grapefruit, mandarin, and sweet orange fruit imported from Botswana is High.**

3.2.3. *Dacus ciliatus* (Diptera: Tephritidae)

The lesser pumpkin fly is a highly mobile, polyphagous pest (Keçe et al., 2019). Adult flies produce an average of 210 eggs and insert them into soft fruits and vegetables. The larvae feed inside the fruit and emerge to pupate in the soil. Several generations occur annually (Azab and Kira, 1954; CABI, 2024; Fetoh, 2006). The wild growing melon, *Citrullus colocynthis*, is believed to be the main reservoir host from which crops become infested (White and Elson-Harris, 1992).

**The endangered area for *Dacus ciliatus* within the United States**

*Climatic suitability:* *Dacus ciliatus* is present in **Africa:** Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Comoros, Cote d'Ivoire, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Lesotho, Malawi, Mauritius, Mayotte, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Saint Helena, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe; **Asia:** Bangladesh, India, Iran, Iraq, Israel, Jordan, Nepal, Oman, Pakistan, Saudi Arabia, Sri Lanka, United Arab Emirates, Yemen; and **Europe:** Turkey (EPPO, 2024). These areas encompass Plant Hardiness Zones 8 to 13 (Takeuchi et al., 2018). In the United States, these areas include the southern continental United States, the eastern and western coasts of the continental United States, Hawaii, Puerto Rico, and other U.S. territories.

*Hosts in United States:* *Dacus ciliatus* mainly infests the fruits of the **Cucurbitaceae** family; including the genera *Citrullus* (melon), *Cucumis* (cantaloupe), *Cucurbita* (squash), *Lagenaria* (gourd), *Luffa*, *Momordica*, and *Trichosanthes*. Researchers have also observed the fly laying eggs in non-cucurbitaceous taxa, such as **Anacardiaceae:** *Mangifera* (mango); **Myrtaceae:** *Psidium guajava* (guava); **Rutaceae:** *Citrus*, including *C. reticulata* (tangerine) and *C. sinensis* (sweet orange); and **Solanaceae:** *Capsicum* (pepper) and *Solanum* (tomato) (Azab and Kira, 1954; Kambura et al., 2018; Kambura, 2016; Kapoor, 1970; Weems, 2002; White, 2006; White and Elson-Harris, 1992).

*Economically important hosts*[8]*:* Some economically important hosts in the United States (NRCS, 2024) include cucumber, guava, eggplant, mango, melon, pepper, pumpkin, sweet orange, tangerine, tomato, and zucchini (NASS, 2019).

*Potential consequences on economically important hosts at risk:* This pest is likely to cause unacceptable consequences because *D. ciliatus* is polyphagous, highly mobile, and is a pest in its historic range (Kambura et al., 2018; Weems, 2002; White, 2006). The pest oviposits causing punctures which cause blemishes or deformities in the fruit, and larval tunnel through fruit (CABI, 2024; White and Elson-Harris, 1992) which predisposes the fruit to infection by secondary organisms of decay.

***Endangered area:*** The endangered area includes areas in Plant Hardiness Zones 8 to 13 where host plants are present.

[8] As defined by ISPM No. 5, potential economic importance applies to crops, the environment (ecosystems, habitats, or species), and to other specified values such as tourism, recreation and aesthetics (IPPC, 2022).

**The likelihood of entry of *Dacus ciliatus* into the endangered area via mandarin and sweet orange fruit imported from Botswana**

| Risk Element | Risk Rating | Uncertainty Rating | Evidence for rating (and other notes as necessary) |
|---|---|---|---|
| Pest prevalence on the harvested commodity | Medium | Low | The lesser pumpkin fly mainly uses Cucurbitaceae as a host; however, it also attacks citrus (Isabirye et al., 2016), including sweet oranges and tangerines (Kambura et al., 2018). Typically, the lesser pumpkin fly infests injured citrus fruits or dropped fruits on the ground (Kambura et al., 2018).<br><br>Kambura (2016) collected fruit to determine fruit fly associations; two adult *D. ciliatus* emerged from one kilogram of sweet orange fruit and one adult *D. ciliatus* emerged from one kilogram of tangerine fruit. Therefore, we chose a risk rating of Medium. |
| Likelihood of surviving post-harvest processing before shipment | Low | Low | No post-harvest processes were considered other than culling of visibly and conspicuously damaged fruit. Fruit fly eggs are inserted within the fruit tissue and larvae are internal feeders. (White and Elson-Harris, 1992). In citrus, the lesser pumpkin fly generally infests injured or dropped fruits (Kambura et al., 2018). Another source states that there are signs of oviposition punctures, such as necrosis (CABI, 2024). Injured or rotting citrus fruits would be culled. Therefore, we lowered the risk rating to Low. |
| Likelihood of surviving transport and storage conditions of the consignment | Low | Negligible | No transport or storage conditions were considered; therefore, we maintain a risk rating of Low. |
| **Overall Likelihood of Entry** | Low | n/a | n/a |

**The likelihood of establishment of *Dacus ciliatus* into the endangered area via mandarin and sweet orange fruit imported from Botswana**

| Risk Element | Risk Rating | Uncertainty Rating | Evidence for rating (and other notes as necessary) |
|---|---|---|---|
| Likelihood of Establishment | Medium | Low | *Dacus ciliatus* has a somewhat narrow host range and host plants (primarily cucurbits) may not always be available. However, tropical fruit fly species are strong fliers with a considerable capacity for long-distance displacements (Díaz-Fleischer and Aluja, 1999). Numerous larvae can infest a single fruit (White and Elson-Harris, 1992), allowing for individual flies to find a mate easily. Therefore, we chose a risk rating of Medium. |
| **Overall Likelihood of Establishment** | Medium | n/a | n/a |

**The likelihood of introduction (combined likelihoods of entry and establishment) of *Dacus ciliatus* into the endangered area via mandarin and sweet orange fruit imported from Botswana is Medium.**

3.2.4. *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae)

The false codling moth is a major pest of citrus, guava, lychee, and avocado (van den Berg et al., 2001). Primary damage is caused by larvae boring into fruits (Hill, 1983). Opportunistic secondary fungal and bacterial rots may cause further damage to fruits or bolls (van der Geest et al., 1991; Erichsen and Schoeman, 1994). A flight range of up to 1.5 km has been recorded (Stotter, 2009). Fecundity typically is about 100 eggs per female; there may be six generations per year (Anonymous, 1960).

**The endangered area for *Thaumatotibia leucotreta* within the United States**

*Climatic suitability:* **Africa:** Angola, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Cote d'Ivoire, Democratic Republic of the Congo, Eritrea, Eswatini, Ethiopia, Gambia, Ghana, Kenya, Madagascar, Malawi, Mali, Mauritius, Mozambique, Niger, Nigeria, Reunion, Rwanda, Saint Helena, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, Zimbabwe; **Asia:** Israel; and **Europe:** Czech Republic (transient) (EPPO, 2024). These areas encompass Plant Hardiness Zones 10 to 13 (Takeuchi et al., 2018). In the United States, these Plant Hardiness Zones include the eastern, southern, and western coasts of the continental United States, Hawaii, Puerto Rico, and other U.S. territories.

*Hosts in United States:* Hosts in the United States include **Asclepiadaceae:** *Calotropis procera* (roostertree); **Euphorbiaceae:** *Ricinus communis* (castorbean); **Fabaceae:** *Phaseolus lunatus* (sieva bean), *Vigna unguiculata* (cowpea); **Juglandaceae:** *Juglans regia* (walnut); **Lauraceae:** *Persea americana* (avocado); **Malvaceae:** *Abelmoschus esculentus* (okra), *Gossypium hirsutum* (cotton), *Hibiscus cannabinus* (brown Indianhemp); **Musaceae:** *Musa* × *paradisiaca* (French plantain); **Myrtaceae:** *Psidium guajava* (guava); **Oleaceae:** *Olea europaea* (olive); **Poaceae:**

*Pennisetum purpureum* (elephant grass), *Zea mays* (corn); **Punicaceae:** *Punica granatum* (pomegranate); **Rhamnaceae:** *Ziziphus ziziphus* (common jujube); **Rosaceae:** *Prunus armeniaca* (apricot), *P. persica* (peach); **Rubiaceae:** *Coffea arabica* (coffee); **Rutaceae:** *Citrus paradisi* (grapefruit), *C. reticulata* (tangerine), *C. sinensis* (orange); **Solanaceae:** *Capsicum annuum* (pepper), *Solanum melongena* (eggplant) (Buadu et al., 2002; Gunn, 1921; NRCS, 2024; Roméo et al., 2015; Stephan et al., 2016; Whittle, 1984).

*Economically important hosts*[9]*:* Apricot, avocado, coffee, corn, cotton, eggplant, grapefruit, guava, okra, olive, sweet orange, peach, pepper, tangerine, and walnut (NASS, 2019).

*Potential consequences on economically important hosts at risk:* This pest is likely to cause unacceptable consequences because the moth can cause losses up to 80 percent in avocado in South Africa (van den Berg et al., 2001). Lesions caused by feeding larvae also reduce the marketability of avocado fruit (Grové et al., 1999). In peach crops in South Africa, losses as high as 28 percent have been reported (Blomefield, 1989). The moth is occasionally an important pest of cotton (Whittle, 1984). Up to 90 percent of total fruit drop in citrus has been attributed to infestation by the false codling moth (Newton, 1998).

***Endangered area:*** The endangered area includes areas in Plant Hardiness Zones 10 to 13 where host plants are present.

[9] As defined by ISPM No. 5, potential economic importance applies to crops, the environment (ecosystems, habitats, or species), and to other specified values such as tourism, recreation and aesthetics (IPPC, 2022).

**The likelihood of entry of *Thaumatotibia leucotreta* into the endangered area via grapefruit, mandarin, and sweet orange fruit imported from Botswana**

| Risk Element | Risk Rating | Uncertainty Rating | Evidence for rating (and other notes as necessary) |
|---|---|---|---|
| Pest prevalence on the harvested commodity | High | Low | *Thaumatotibia leucotreta* is an important pest of citrus, and eggs are laid on the fruit of its host plants, including *Citrus* spp. (Newton, 1998; Trematerra, 2023). Larvae emerge and bore into the fruit, feeding below the surface (Newton, 1998; Trematerra, 2023). Therefore, we used a risk rating of High. |
| Likelihood of surviving post-harvest processing before shipment | High | Low | No post-harvest processes were considered other than culling of visibly and conspicuously damaged fruit. *Thaumatotibia leucotreta* eggs are small, flat, and translucent and often laid inconspicuously in the depressions of the fruit skin (Newton, 1998; Prinsloo and Uys, 2015); therefore, eggs may evade detection. Larvae feed on fruit internally (CABI, 2024), and recently-attacked fruit with early instar larvae would also likely evade detection (Georgala, 1969). Therefore, we maintain a risk rating of High. |
| Likelihood of surviving transport and storage conditions of the consignment | High | Negligible | No transport or storage conditions were considered; therefore, we maintain a risk rating of High. |
| **Overall Likelihood of Entry** | High | n/a | n/a |

**The likelihood of establishment of *Thaumatotibia leucotreta* into the endangered area via grapefruit, mandarin, and sweet orange fruit imported from Botswana**

| Risk Element | Risk Rating | Uncertainty Rating | Evidence for rating (and other notes as necessary) |
|---|---|---|---|
| Likelihood of Establishment | Low | Moderate | *Thaumatotibia leucotreta* is polyphagous and cultivated and wild hosts are available throughout the endangered area (NRCS, 2024). Additionally, adults are capable of flying; a flight range of up to 1.5 km has been recorded for *Thaumatotibia leucotreta* (Stotter, 2009). However, the egg or larva stage would be the most likely life stage to move with the commodity. To establish, eggs would need to hatch and/or larvae would need to complete development, pupate in soil, mate, and locate a suitable host prior to citrus being consumed or disposed of in a landfill or compost where the chances of survival are probably significantly reduced. Usually, only a single larva develops per fruit (Ford, 1934; Newton, 1998); thus, adults would emerge in isolation making it difficult to locate a mate. Therefore, we have assigned a risk rating of Low. |
| **Overall Likelihood of Establishment** | Medium | n/a | n/a |

**The likelihood of introduction (combined likelihoods of entry and establishment) of *Thaumatotibia leucotreta* into the endangered area via grapefruit, mandarin, and sweet orange fruit imported from Botswana is Medium.**

## 4. Summary

The following pests are considered quarantine significant for the PRA area. The pests have a reasonable likelihood of following the commodity pathway and would likely cause unacceptable consequences if introduced into the PRA area (Table 3). Thus, the pests are candidates for risk management.

**Table 3**. Summary of quarantine pests that are candidates for risk management

| Pest type | Scientific name | Likelihood of Introduction[10] | Notes | *Citrus* species affected |
|---|---|---|---|---|
| INSECT | *Bactrocera dorsalis* (Hendel) | n/a | 7 CFR § 301.32, 2023 | CL, CP, CR, CS |
| INSECT | *Ceratitis capitata* (Wiedemann) | n/a | 7 CFR § 301.32, 2023 | CL, CP, CR, CS |
| INSECT | *Ceratitis cosyra* (Walker) | High | | CL, CP, CR, CS |
| INSECT | *Ceratitis rosa* Karsch | High | | CP, CR, CS |
| INSECT | *Dacus ciliatus* Loew | Medium | | CR, CS |
| INSECT | *Thaumatotibia leucotreta* (Meyrick) | Medium | | CP, CR, CS |
| FUNGI | *Phyllosticta citricarpa* (McAlpine) Aa; syn. *Guignardia citricarpa* Kiely | n/a | Federal Order DA-2012-09 (USDA-APHIS, 2012) | CL, CP, CR, CS |

Our assessment of risk is contingent on the application of all components of the pathway as described in section 1.4. The detailed examination and choice of appropriate phytosanitary measures to mitigate pest risk are addressed in a separate document.

[10] n/a: The likelihood of introduction was not assessed for Select Agents and Program Pests - federal regulations are in place for these pests because they were previously determined to pose an unacceptable risk to U.S. agriculture or natural resources.

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# 6. Appendix: Pests with non-quarantine status

We found evidence that the organisms listed below are associated with grapefruit, lemon, sweet orange, and mandarin and are present in Botswana; however, none are of quarantine significance for the United States (ARM, 2024, or as defined by ISPM No. 5). Although we did not intensively evaluate the evidence, we provide references supporting each pest's potential presence in Botswana, presence in the United States (if applicable), and association with the grapefruit, lemon, sweet orange, and mandarin. If any of the organisms are **not** present in the United States, we also provided justification for their non-quarantine status. Unless otherwise noted, these organisms are non-actionable at U.S. ports of entry (ARM, 2024).

| **Organism** | **In Botswana** | **In U.S.** | **Host Association** | **Notes** |
|---|---|---|---|---|
| INSECT<br>Hemiptera: Coccidae<br>*Coccus hesperidum* Linnaeus | BMADFS, 2022 | García-Morales et al., 2016 | CL, CP, CR, CS (García-Morales et al., 2016) | |
| INSECT<br>Hemiptera: Coccidae<br>*Parasaissetia nigra* (Nietner) | BMADFS, 2022 | García-Morales et al., 2016 | CL, CR (García-Morales et al., 2016) | |
| INSECT<br>Hemiptera: Coccidae<br>*Saissetia oleae* (Olivier) | BMADFS, 2022 | García-Morales et al., 2016 | CL, CP, CR, CS (García-Morales et al., 2016) | |
| INSECT<br>Hemiptera: Coreidae<br>*Leptoglossus gonagra* (Fabricius) | CABI, 2024 | Texas A&M University Insect Collection, 2024 | CR, CP, CS (Mitchell, 2000) | |
| INSECT: Hemiptera: Diaspididae[11]<br>*Aonidiella aurantii* (Maskell) | BMADFS, 2022 | García-Morales et al., 2016 | CL, CP, CR, CS (García-Morales et al., 2016) | |
| INSECT<br>Hemiptera: Diaspididae<br>*Chrysomphalus aonidum* (Linnaeus) | BMADFS, 2022 | García-Morales et al., 2016 | CL, CP, CR, CS (García-Morales et al., 2016) | |
| INSECT<br>Hemiptera: Diaspididae<br>*Ischnaspis longirostris* (Signoret) | BMADFS, 2022 | García-Morales et al., 2016 | CP, CS (García-Morales et al., 2016) | |

[11] All armored scales (Diaspididae) are non-actionable at U.S. ports of entry on fruits and vegetables for consumption (NIS, 2008). Therefore, we did not need to determine whether they occur in the United States.

| Organism | In Botswana | In U.S. | Host Association | Notes |
|---|---|---|---|---|
| INSECT<br>Hemiptera: Diaspididae<br>*Lepidosaphes beckii* (Newman) | BMADFS, 2022 | García-Morales et al., 2016 | CL, CP, CR, CS (García-Morales et al., 2016) | |
| INSECT<br>Hemiptera: Monophlebidae<br>*Icerya purchasi* Maskell | BMADFS, 2022 | García-Morales et al., 2016 | CL, CR, CS (García-Morales et al., 2016) | |
| INSECT<br>Hemiptera: Pseudococcidae<br>*Planococcus citri* (Risso) | BMADFS, 2022 | García-Morales et al., 2016 | CL, CP, CR, CS (García-Morales et al., 2016) | |
| INSECT<br>Hemiptera: Pseudococcidae<br>*Pseudococcus longispinus* (Targioni Tozzetti); syn. *Pseudococcus adonidum* | BMADFS, 2022 | García-Morales et al., 2016 | CL, CP, CR, CS (García-Morales et al., 2016) | |
| INSECT<br>Lepidoptera: Gracillariidae<br>*Phyllocnistis citrella* Stainton | BMADFS, 2022 | CABI, 2024 | CL, CP, CR, CS (CABI, 2024) | |
| INSECT<br>Lepidoptera: Noctuidae<br>*Spodoptera frugiperda* J.E. Smith | CABI, 2024 | CABI, 2024 | CL, CR, CS (CABI, 2024) | |
| MITE<br>Prostigmata: Tetranychidae<br>*Tetranychus urticae* Koch; syn. *Tetranychus cinnabarinus* (Boisduval) | Legwaila et al., 2021 | CABI, 2024 | CL, CS (CABI, 2024) | |
| MITE<br>Trombidiformes: Eriophyidae<br>*Aceria sheldoni* (Ewing) | BMADFS, 2022 | Boyce and Korsmeier, 1941; Childers et al., 2017; Klompen and Johnson, 2018 | CL, CP, CR, CS (CABI, 2024) | |
| MITE<br>Trombidiformes**:** Eriophyidae<br>*Phyllocoptruta oleivora* Ashmead | BMADFS, 2022 | CABI, 2024 | CL, CP, CR, CS (CABI, 2024) | |
| CHROMISTAN<br>*Phytophthora capsici* Leonian | CABI, 2024 | CABI, 2024 | CR (Cheng et al., 2014) | |
| CHROMISTAN<br>*Phytophthora citrophthora* (R.E. Sm. & E.H. Sm.) Leonian | BMADFS, 2022 | Farr and Rossman, 2024 | CL, CP, CR, CS (Farr and Rossman, 2024) | |

| Organism | In Botswana | In U.S. | Host Association | Notes |
|---|---|---|---|---|
| CHROMISTAN *Phytophthora nicotianae* Breda de Haan | BMADFS, 2022 | Farr and Rossman, 2024 | CL, CS (Farr and Rossman, 2024) | |
| FUNGI *Alternaria citri* Ellis & N. Pierce | BMADFS, 2022; Farr and Rossman, 2024; Crous et al., 2000 | CABI, 2024 | CL, CR, CS, CP (Crous et al., 2000; BMADFS, 2022; Farr and Rossman, 2024; CABI, 2024) | |
| FUNGI *Athelia rolfsii* (Curzi) C.C. Tu & Kimbr. syn. Corticium rolfsii Curzi | CABI, 2024 | CABI, 2024 | CL (CABI, 2024; Pane et al., 2008) | |
| FUNGI *Capnodium salicinum* Mont. & *Capnodium citri* Penz. | CABI, 2024 | CABI, 2024; Farr and Rossman, 2024 | CR, CS (CABI, 2024; Farr and Rossman, 2024) | |
| FUNGI *Cercospora penzigii* Sacc. | BMADFS, 2022 | No evidence found | *Citrus* sp. (CABI, 2024; Farr and Rossman, 2024; Pretorius et al., 2003; BMADFS, 2022) | |
| FUNGI *Elsinoë fawcettii* Bitanc. & Jenkins | BMADFS, 2022 | Farr and Rossman, 2024 | CL, CP, CR, CS (Farr and Rossman, 2024) | |
| FUNGI *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk. Syn: *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. | Farr and Rossman, 2024; BMADFS, 2022 | WPFUS, 2018; Farr and Rossman, 2024 | CP, CR, CS (Farr and Rossman, 2024) | |

| **Organism** | **In Botswana** | **In U.S.** | **Host Association** | **Notes** |
|---|---|---|---|---|
| FUNGI<br>*Macrophomina phaseolina* (Tassi) Goid. | CABI, 2024 | CABI, 2024; WPFUS, 2018 | CL, CS, CR (Farr and Rossman, 2024) | |
| FUNGI<br>*Penicillium digitatum* (Pers. : Fr.)<br>Sacc. | BMADFS, 2022 | Farr and Rossman, 2024 | CL, CP, CR, CS (CABI, 2024) | |
| FUNGI<br>*Penicillium italicum* Wehmer | BMADFS, 2022 | Farr and Rossman, 2024 | CL (Farr and Rossman, 2024)<br><br>CP, CR, CS (CABI, 2024) | |
| FUNGI<br>*Sphaceloma fawcettii* Jenkins.<br>Syn: *Elsinoë fawcettii* Bitanc. & Jenkins | BMADFS, 2022; Crous et al., 2000 | CABI, 2024; Farr and Rossman, 2024 | CL, CR, CS, CP (CABI, 2024; Timmer et al., 2000) | |