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# Importation of Fresh Leaves and Stems of Garland Chrysanthemum, *Glebionis coronarium*, from Mexico into the Entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands

# A Qualitative, Pathway-Initiated Pest Risk Assessment

**Agency Contact**:

Plant Epidemiology and Risk Analysis Laboratory
Center for Plant Health 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 risk assessment to examine plant pest risks associated with importing commercially-produced fresh leafy greens (i.e., stems and leaves) of garland chrysanthemum, *Glebionis coronarium* (Asteraceae), for consumption from Mexico into the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands. Based on the market access request submitted by Mexico, we considered the pathway to include the following processes and conditions: Greens from the field will be harvested by hand 45 days prior to flowering and examined for color and wholeness of leaves. Harvested greens will be immediately transferred to cartons that will be protected with plastic while in the field. Greens will be cooled to 1°C for 40 minutes and then stored in a cold room until they are loaded for refrigerated transport. When awaiting loading into the truck, cartons will be protected with screens. The risk ratings in this risk assessment are contingent upon the application of all components of the pathway as described in this document. Stems and leaves produced under different conditions were not evaluated in this PRA and may have a different pest risk.

Based on the scientific literature, port-of-entry pest interception data, and information from the government of Mexico, we developed a list of all potential pests with actionable regulatory status for the United States that are known to occur in Mexico (on any host) and to be associated with the commodity plant species (anywhere in the world). Of these, we found five organisms that have a reasonable likelihood of being associated with the commodity following harvesting from the field and prior to any post-harvest processing and thus are potentially able to follow the pathway.

We analyzed the pest risk potential of these organisms and determined that the following two are not candidates for risk management because they received a Negligible overall risk rating for likelihood of introduction (i.e., entry plus establishment) into the endangered area via the import pathway: *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) and '*Candidatus* Phytoplasma asteris' (Acholeplasmatales: Acholeplasmataceae).

The remaining three organisms met the threshold for unacceptable consequences of introduction and had a non-negligible likelihood of introduction. We therefore consider these pests to be candidates for risk management:

| Pest type | Taxonomy | Scientific name | Likelihood of Introduction overall rating |
|---|---|---|---|
| Arthropod | Coleoptera: Curculionidae | *Listroderes costirostris* Schoenherr | Medium |
| | Hemiptera: Miridae | *Lygus lineolaris* (Palisot de Beauvois) | Medium |
| | Lepidoptera: Arctiidae | *Estigmene acrea* (Drury) | Low |

Detailed examination and choice of appropriate phytosanitary measures to mitigate pest risk are part of the pest risk management phase within APHIS and are not addressed in this document.

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# 1. Introduction

## 1.1. Background

This document was prepared by the Plant Epidemiology and Risk Analysis Laboratory of the Center for Plant Health Science and Technology, USDA Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) to evaluate the pest risk associated with the importation of commercially-produced fresh stems and leaves of garland chrysanthemum, *Glebionis coronarium* (L.) Tzvelev, for consumption from Mexico into the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands.

This is a qualitative risk assessment, meaning that the likelihood and consequences of pest introduction are expressed as qualitative ratings rather than in numerical terms. Methodology and rating criteria used are detailed in the *Guidelines for Plant Pest Risk Assessment of Imported Fruit and Vegetable Commodities* (PPQ, 2012). 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, 2017). The use of biological and phytosanitary terms is consistent with ISPM No. 5, "Glossary of Phytosanitary Terms" (IPPC, 2018).

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, 2012). Under this regulation, the entry of garland chrysanthemum, *Glebionis coronarium*, from Mexico into the United States for consumption is not currently authorized. This commodity risk assessment was initiated due to a request by Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria (SENASICA) to change the Federal Regulation to allow entry of garland chrysanthemum leafy greens for consumption (Trujillo-Arriaga, 2017).

## 1.3. Determination of the necessity of a weed risk assessment for the commodity

In some cases, an imported commodity could become invasive in the pest risk analysis (PRA) area. If warranted, the pest risk posed by the commodity itself is evaluated in a weed risk assessment, conducted separately from the commodity risk assessment.

Weed risk assessments are unnecessary for plant species that are widely established (native or naturalized) or cultivated in the PRA area, for commodities that are already enterable into the PRA area from other countries, or for plant parts that cannot easily propagate on their own or be propagated. We determined that a weed risk assessment is not needed for *Glebionis coronarium* because the commodity is an annual plant (Teja et al., 2017) that cannot be propagated vegetatively. Furthermore, seeds will not be collected with the commodity, as it will be harvested prior to flowering (Golden-Fields, 2014).

## 1.4. Description of the pathway

A pathway is "any means that allows the entry or spread of a pest" (IPPC, 2018). In the context of this risk assessment, 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. In this risk assessment, the specific pathway of concern is the importation of the fresh leafy greens of garland chrysanthemum, *Glebionis coronarium* for consumption from Mexico into the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands; the movement of this commodity provides a potential pathway for the introduction or spread of plant pests. The following description of this pathway focuses on the conditions that may affect plant pest risk, including morphological and physiological characteristics of the commodity and processes that the commodity will undergo from production in Mexico through importation and distribution in the United States. These conditions provide the basis for creating the pest list and assessing the likelihood of introduction of the pests selected for further analysis. Hence, the risk ratings in this risk assessment are contingent upon the application of all components of the pathway as described.

### 1.4.1. Description of the commodity

The commodity to be imported for consumption is fresh leafy greens of garland chrysanthemum, *Glebionis coronarium* (L.) Tzvelev (syn.: *Chrysanthemum coronarium* L.). The stems and leaves will be harvested approximately 45 days prior to flowering, so flowers will not be part of the commodity. Roots will also not be harvested.

### 1.4.2. Production and harvest procedures in the exporting area

Greens grown in the field will be harvested by hand 45 days prior to flowering and examined for color and wholeness of leaves. Harvested greens will be immediately transferred to cartons that will be protected with plastic in the field (Golden-Fields, 2014).

### 1.4.3. Post-harvest procedures in the exporting area

Greens will be cooled to 1°C for 40 minutes and then stored in a cold room until they are loaded for refrigerated transport. While awaiting loading into the truck, cartons will be protected with screens (Golden-Fields, 2014).

### 1.4.4. Shipping and storage conditions

Greens will be stored in a cold room until they are loaded for refrigerated transport (Golden-Fields, 2014).

### 1.4.5. Summary of the pathway

Figure 1 summarizes the pathway of concern: the importation of fresh leafy greens of garland chrysanthemum, *Glebionis coronarium,* for consumption from Mexico into the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands.

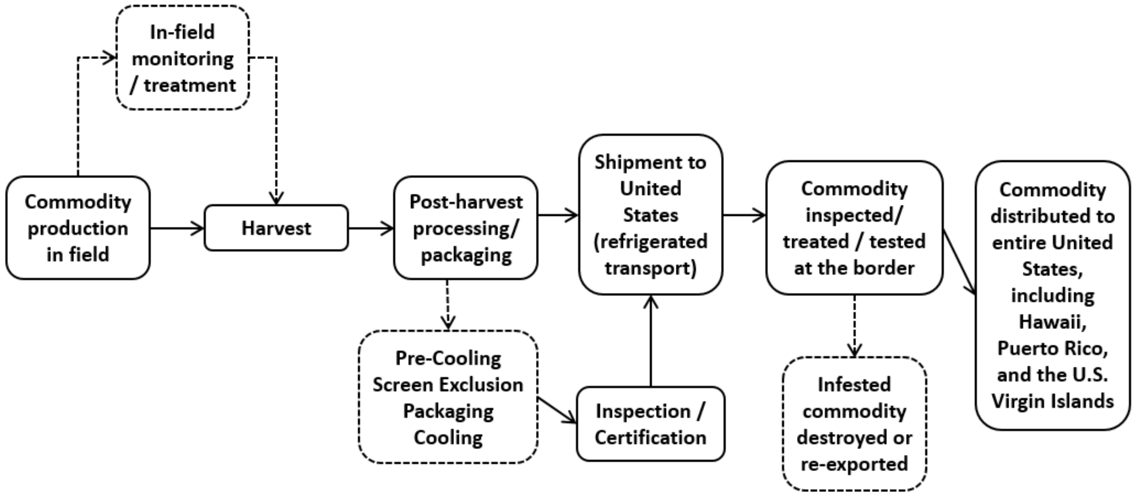


**Figure 1**. Pathway diagram for imports of garland chrysanthemum from Mexico into the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands.

## 2. Pest List and Pest Categorization

The pest list is a compilation of all plant pests with actionable regulatory status for the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands, that are present in Mexico (on any host) and associated with *Glebionis coronarium* (anywhere in the world). Species on the pest list with a reasonable likelihood of being present on garland chrysanthemum at the time of harvest could follow the pathway into the United States and are therefore assessed in more detail to determine their pest risk potential. Pests are considered to be of regulatory significance if they are actionable at U.S. ports of entry. Actionable pests include quarantine pests, regulated non-quarantine pests, pests under official control or considered for official control, and pests that require evaluation for regulatory action.

### 2.1. Pests considered but not included on the pest list

2.1.1. Pests with weak evidence for association with the commodity or for presence in the export area

***Neochetina eichhorniae*** Warner (Coleoptera: Brachyceridae): This beetle is present in both Mexico and the United States. It was introduced as a biocontrol agent against water hyacinth (Aguilar et al., 2003). One reference reports that it feeds on *Glebionis coronarium* in a laboratory setting (Shih et al., 1994), but the beetle cannot complete its lifecycle on any plant except water hyacinth. We considered its association with *Glebionis coronarium* as insufficient to consider the plant a natural host, so we did not include this beetle on the pest list.

***Dicyphus hesperus*** Knight (Hemiptera: Miridae): This insect is present in Mexico (Gillespie and Quiring, 2005), and two references report that it feeds on *Glebionis coronarium* in laboratory settings (Sanchez et al., 2004; VanLaerhoven et al., 2006). Within the laboratory setting, the insect does not complete its lifecycle on *Glebionis coronarium* without supplemental insect eggs on which to feed (Sanchez et al., 2004). We considered this association with *Glebionis* *coronarium* to be insufficient evidence that the plant is a natural host, so we did not include this insect on the pest list.

***Tomato chlorotic dwarf viroid:*** This species is present in the continental United States (CABI, 2018a; Ling et al., 2009). We did not find records of its occurrence in Hawaii, Puerto Rico, or the U.S. Virgin Islands. Infection of *G. coronarium* was under experimental conditions (Matsushita et al., 2009), and the pathogen in Mexico was reported from a greenhouse environment (Ling et al., 2009). Because of the insufficient evidence surrounding *G. coronarium* as a natural host and the lack of evidence for distribution in Mexico beyond a greenhouse environment, the viroid was not included on the pest list. Symptomatic viroid-infected plants would likely be discarded at harvest. This viroid is spread by contaminated tools (BCMA, 2016; Matsushita et al., 2009) and therefore is not likely to be able to move from infected greens to new host plants in the United States.

2.1.2. Organisms with non-actionable regulatory status

We found evidence of the organisms listed in the Appendix as being associated with garland chrysanthemum and being present in Mexico; however, because these organisms have non-actionable regulatory status for the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands we did not include them in Table 1 of this risk assessment.

PPQ considers armored scales (Hemiptera: Diaspididae) non-actionable at U.S. ports of entry on fruit and vegetables intended for consumption (NIS, 2008). Even if armored scale species are not present in the PRA area, these insects are highly unlikely to establish via this pathway due to their very limited ability to disperse to new host plants (Miller et al., 1985; PERAL, 2007). For this reason, armored scales are not included in Table 1 but are included in the Appendix.

## 2.2. Pest list

In Table 1, we list the actionable pests associated with garland chrysanthemum that occur in Mexico. The list includes those actionable pests that occur in Mexico on any host and are associated with garland chrysanthemum whether in Mexico or elsewhere in the world. For each pest, we indicate 1) the part of the imported plant species with which the pest is generally associated and 2) whether the pest has a reasonable likelihood of being associated, in viable form, with the commodity 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 Mexico. Pests in shaded rows are identified for further evaluation, as we consider them reasonably likely to be associated with the harvested commodity. We summarize the information for these pests in a separate table (Table 2).

**Table 1**. Actionable pests associated with *Glebionis coronarium* (in any country) and present in Mexico (on any host).

| Pest name | Evidence of presence in Mexico | Association with *Glebionis coronarium*[1] | Plant part(s) association[2] | On harvested plant part(s)?[3] | Remarks |
|---|---|---|---|---|---|
| **INSECTA** | | | | | |
| **COLEOPTERA** | | | | | |
| **Curculionidae** | | | | | |
| *Listroderes costirostris* Schoenherr | McClay et al., 1995 | Hsu and Chiang, 1983 | Roots, leaves, stems [Extrapolated from other plant species (CABI, 2018a; Friedman, 2009; d'Araujo et al., 1968)] | Yes | Present in the continental United States and Hawaii (Friedman, 2009); however, no evidence of presence in Puerto Rico or the U.S. Virgin Islands. |
| **HEMIPTERA** | | | | | |
| **Miridae** | | | | | |
| *Lygus lineolaris* (Palisot de Beauvois) | Trujillo-Arriaga, 2017 | Trujillo-Arriaga, 2017 | Leaves (Trujillo-Arriaga, 2017) | Yes | Present in the continental United States (Young, 1986); however, no evidence of presence in Hawaii, Puerto Rico, or the U.S. Virgin Islands. |
| **Pseudococcidae** | | | | | |

[1] If warranted, the host type (i.e., Type 1, Type 2, or Type 4 host) may be indicated for a pest. Host types are explained in *Guidelines for Plant Pest Risk Assessment of Imported Fruit and Vegetable Commodities* (PPQ, 2012).

[2] 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.

[3] "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 in Risk Element A1 as part of the Likelihood of Introduction assessment (section 3).

| Pest name | Evidence of presence in Mexico | Association with *Glebionis coronarium*[1] | Plant part(s) association[2] | On harvested plant part(s)?[3] | Remarks |
|---|---|---|---|---|---|
| *Maconellicoccus hirsutus* (Green) | CABI, 2018a; Zhang et al., 2004 | Ben-Dov, 1994; Padilla, 2000 | Inflorescence, leaves, stems, and fruits [extrapolated from other plant species (CABI, 2018a)] | Yes | Present in California (Roltsch et al., 2006), Florida (Francis et al., 2007), Hawaii (Ben-Dov, 1994; Nishida, 2002), the U.S. Virgin Islands (Serrano et al., 2001), and Puerto Rico (Michaud and Evans, 2000). Reportable / actionable in PestID (PestID, 2018). |
| **LEPIDOPTERA** | | | | | |
| **Arctiidae** | | | | | |
| *Estigmene acrea* (Drury) | Trujillo-Arriaga, 2017; Young and Sifuentes, 1959 | Trujillo-Arriaga, 2017 | Leaves (Trujillo-Arriaga, 2017) | Yes | Present in the continental United States (Willis and Birch, 1982); however, no evidence of presence in Hawaii, Puerto Rico, or the U.S. Virgin Islands. |
| **THYSANOPTERA** | | | | | |

| Pest name | Evidence of presence in Mexico | Association with *Glebionis coronarium*[1] | Plant part(s) association[2] | On harvested plant part(s)?[3] | Remarks |
|---|---|---|---|---|---|
| **Aeolothripidae** | | | | | |
| *Aeolothrips collaris* Priesner | Ruiz-De La Cruz et al., 2013 | Marullo, 2002 | Flowers [extrapolated from other plant species (Marullo, 2004)]. | No | Present in the continental United States (Hoddle et al., 2004); however, no evidence of presence in Hawaii, Puerto Rico, or the U.S. Virgin Islands. |
| **FUNGI** | | | | | |
| *Puccinia horiana* Henn. | CABI, 2018b; EPPO, 2018 | González and Montealegre, 1981; NAPPO, 2007 | Leaves (MacDonald, 2001), bracts, stems, and flowers (CABI, 2018b) | Yes | See comments in section 2.3. |
| **PHYTOPLASMA** | | | | | |
| ‘*Candidatus* Phytoplasma asteris’ | CABI, 2018a; Pérez-López et al., 2016 | CABI, 2018a; Lee et al., 2004 | Whole plant (CABI, 2018a) | Yes | Present in the continental United States (CABI, 2018a) and Hawaii (Widely Prevalent Bacteria of the United States, 2018); however, no evidence of presence in Puerto Rico or the U.S. Virgin Islands. |

### 2.3 Notes on pests identified in the pest list

***Puccinia horiana***: This species is a quarantine-significant pest for the United States (PestID, 2018). *Puccinia horiana* grows and reproduces only on certain susceptible plant species of chrysanthemum (USDA-APHIS, 2015). Fresh greens for consumption of *Glebionis coronarium* and synonyms are reported to be resistant, showing no symptoms when inoculated with this pest (Dickens, 1968; EPPO, 2018), therefore, it is not being considered for further analysis.

### 2.4. Pests selected for further analysis

We identified five pests for further analysis (Table 2). All of these organisms are actionable pests for some combination of the continental United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands and also have a reasonable likelihood of being associated with the commodity plant parts at the time of harvest and remaining with the commodity, in viable form, throughout the harvesting process.

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

| Pest type | Taxonomy | Scientific name |
|---|---|---|
| Arthropod | Coleoptera: Curculionidae | *Listroderes costirostris* (for Puerto Rico and the U.S. Virgin Islands only) |
| | Hemiptera: Miridae | *Lygus lineolaris* (for Hawaii, Puerto Rico, and the U.S. Virgin Islands only) |
| | Hemiptera: Pseudococcidae | *Maconellicoccus hirsutus* (for the continental United States only) |
| | Lepidoptera: Arctiidae | *Estigmene acrea* (for Hawaii, Puerto Rico, and the U.S. Virgin Islands only) |
| Phytoplasma | Acholeplasmatales: Acholeplasmataceae | '*Candidatus* Phytoplasma asteris' (for Puerto Rico and the U.S. Virgin Islands only) |

## 3. Assessing Pest Risk Potential

### 3.1. Introduction

For each pest selected for further analysis, we estimate its overall pest risk potential. Risk is described by the likelihood of an adverse event, the magnitude of the consequences, and uncertainty. In this risk assessment, we first determine for each pest if there is an endangered area within the PRA area. The endangered area is defined as the portion of the import area where ecological factors favor the establishment of the pest and where the presence of the pest would result in economically important losses. Once an endangered area has been determined, the overall risk of each pest is then determined with two separate components: 1) the likelihood of its introduction into the endangered area on the imported commodity (i.e., the likelihood of an adverse event) and 2) the consequences of its introduction (i.e., the magnitude of the consequences). In general, we assess both of these components for each pest. If we determine that the risk of either component is negligible, however, assessing the other is not necessary because the overall pest risk potential will be negligible regardless of the result of the second component. For example, if we determine that pest introduction is highly unlikely, we do not assess the consequences of its introduction.

The likelihood and consequences of introduction are assessed using different approaches. For the consequences of introduction, we determine if the pest meets the threshold (Yes/No) of being likely to cause unacceptable losses. We base that determination on the physical damage the pest is likely to cause and the proportion of exports likely to be disrupted, rather than on an absolute value or amount of monetary loss.

The likelihood of introduction is based on the likelihoods of entry and establishment. We qualitatively assess risk using the ratings Negligible, Low, Medium, and High. The risk factors determining the model for likelihood of introduction are interdependent, so the model is multiplicative rather than additive. Thus, if any one risk element is rated as Negligible, then the overall likelihood will be Negligible. For the overall likelihood of introduction risk rating, we define the different 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 the full combination of required events is unlikely to align properly in time and space.

Negligible: Pest introduction is highly unlikely to occur given the exact combination of events required for successful introduction.

### 3.2. Assessment results

#### 3.2.1. *Listroderes costirostris*

We determined the overall likelihood of introduction of *Listroderes costirostris* to be Medium. We present the results of this assessment in the following table.

We determined that establishment of *Listroderes costirostris* in Puerto Rico and the U.S. Virgin Islands is likely to cause unacceptable impacts. We present the results of this assessment in the following table.

**Determination of the portion of Puerto Rico and the U.S. Virgin Islands endangered by *Listroderes costirostris***

| | |
|---|---|
| Climatic suitability | *Listroderes costirostris* is present in Argentina (Bartlett et al., 1978), Australia (Bartlett et al., 1978; Friedman, 2009), Brazil (d'Araujo et al., 1968), Bolivia (Morrone, 1993), Chile (Elgueta and Marvaldi, 2006; Friedman, 2009), the United States (Bartlett et al., 1978; Clancy, 1969; Friedman, 2009; Morrone, 1993), Israel (Friedman, 2009), Japan (Japan Plant Protection Association, 1987), South Korea (ESK&KSAE, 1994), Mexico (McClay et al., 1995), New Zealand (Bentancourt and Scatoni, 1999), Paraguay (Morrone, 1993), South Africa (Bartlett et al., 1978), Spain (Morrone, 1993), Taiwan (Hsu and Chiang, 1983), and Uruguay (Bartlett et al., 1978; Bentancourt and Scatoni, 1999).<br><br>These areas encompass Plant Hardiness Zones 7 through 13. Puerto Rico includes Plant Hardiness Zones 12 and 13, and the U.S. Virgin Islands are in Zone 13. The Plant Hardiness Zones of Puerto Rico and the U.S. Virgin Islands are within the range where *L. costirostris* can survive. |

| | |
|---|---|
| Potential hosts at risk in PRA Area | *Listroderes costirostris* is highly polyphagous. This weevil feeds on hog-cress (*Coronopus didymus*) (May, 1966), Santa Maria feverfew (*Parthenium hysterophorus*) (McClay et al., 1995), common sunflower (*Helianthus annuus*) (Morrone, 1993), Mexican-tea (*Dysphania ambrosioides*) (High, 1939), jimsonweed (*Datura stramonium*) (High, 1939), fleabane (*Erigeron* sp.) (High, 1939), pennywort (*Hydrocotyle bonariensis*) (High, 1939), wild lettuce (*Lactuca* sp.) (High, 1939), peppergrass (*Lepidium* sp.) (High, 1939), wild peppergrass (*Lepidium virginicum*) (High, 1939), lady's sorrel (*Oxalis corniculata*) (High, 1939), water smartweed (*Polygonum punctatum*) (High, 1939), spiny-leaved sowthistle (*Sonchus asper*) (High, 1939), Dakota verbena (*Verbena bipinnatifida*) (High, 1939), purslane speedwell (*Veronica peregrina*) (High, 1939), potato (*Solanum tuberosum*) (Bentancourt and Scatoni, 1999; Hassan, 1977), watermelon (*Citrullus lanatus*) (Koch and Waterhouse, 2000) lettuce (*Lactuca sativa*) (Lincango and Morales, 2005), eggplant (*Solanum melongena*) (High, 1939), pepper (*Capsicum annuum*) (High, 1939), sweet potato (*Ipomoea batatas*) (High, 1939), and cabbage (*Brassica oleracea*) (High, 1939). |
| Economically important hosts at risk[a] | Economically important crops this insect feeds on are watermelon (Koch and Waterhouse, 2000), lettuce (Lincango and Morales, 2005), eggplant (High, 1939), bean (High, 1939), pepper (High, 1939), sweet potato (High, 1939), and cabbage (High, 1939). |
| Pest potential on economically important hosts at risk | Injury from this weevil occurs from feeding by both the larvae and the adults. The buds are eaten first, which stunts the plants. Large leaves are eaten next, with the exception of the main stems and larger veins (High, 1939). Leaves may be completely skeletonized (Beckham, 1953). Roots are also fed upon by both larvae and adults (Beckham, 1953). In tomatoes, the insect attacks young plants, resulting in stunting, stand reductions, and lower fruit yields (Beckham, 1953). Crop damage by this weevil varies dramatically from year to year and crop to crop (High, 1939). In 1933, estimated crop losses for tomatoes in Mississippi ranged from five percent to 70 percent (High, 1939), and in 1953, *Listroderes costirostris* severely damaged tobacco in South Carolina (Gentry, 1954). Entire fields of turnips, carrots, cabbages, mustard, and spinach have been destroyed by the early larval stages of the beetle (High, 1939). |
| **Defined Endangered Area** | The area endangered by *Listroderes costirostris* includes any location in Puerto Rico or the U.S. Virgin Islands where economically-important host plants occur. Puerto Rico includes Plant Hardiness Zones 12 and 13, and the U.S. Virgin Islands are in Zone 13. *Listroderes costirostris* can inhabit areas in these Plant Hardiness Zones where host plants occur. |

[a] As defined by ISPM No. 11, supplement 2, "economically-important hosts" refers to both commercial and non-market (environmental) plants (IPPC, 2017).

**Assessment of the likelihood of introduction of *Listroderes costirostris* into the endangered area via the importation of garland chrysanthemum from Mexico**

| Risk Element | Risk Rating | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Likelihood of Entry** | | | |
| Risk Element A1: Pest prevalence on the harvested commodity (= the baseline rating for entry) | High | MC | The eggs or early instar larvae are most likely to be associated with the commodity. Eggs are laid primarily on the crowns of host plants but may also be laid on stems or large leaves (Beckham, 1953). A glutinous secretion adheres the eggs to the plant (High, 1939). Larvae feed on plant tissue both above and below ground, damaging the stems, crowns, and roots of host plants (Miller, 1979). Turnip greens, radishes, and carrots ready for market have been found infested with larvae (Beckham, 1953). Assuming the crop will be harvested during the daytime, adult weevils are unlikely to be present on the commodity, as they only feed at night and stay in leaf litter or near the soil during the day (High, 1939). Pupae are also unlikely to be found on harvested commodity, as they pupate one half to two inches in moist soil (High, 1939). |
| Risk Element A2: Likelihood of surviving post-harvest processing before shipment | High | C | The commodity will not be further handled after the harvesting process (Golden-Fields, 2014). Screens will be used to protect the harvested material from additional insects that may enter the crates. The commodity will be refrigerated post-harvest, but we found no evidence that this would affect the pest population. |
| Risk Element A3: Likelihood of surviving transport and storage conditions of the consignment | High | C | Refrigeration is the only treatment that will occur during the transport and storage of garland chrysanthemum (Golden-Fields, 2014). We found no evidence that this would change the insect population. |
| Risk Element A: Overall risk rating for likelihood of entry | High | N/A | |

| **Risk Element** | **Risk Rating** | **Uncertainty Rating[a]** | **Justification for rating and explanation of uncertainty (and other notes as necessary)** |
|---|---|---|---|
| **Likelihood of Establishment** | | | |
| Risk Element B1: Likelihood of coming into contact with host material in the endangered area | Medium | MC | *Listroderes costirostris* has a broad host range, and those hosts are widely distributed throughout the endangered area. Adult weevils can fly (High, 1939), although one source states that flight is rare (Beckham, 1953). This insect exhibits parthenogenesis (High, 1939), which means females may lay fertile eggs without fertilization from males. The elimination of the mating step in order to produce viable offspring would allow this weevil to establish more readily than species that require sexual reproduction. The most likely life stages to be imported with garland chrysanthemum greens from Mexico would be eggs and early instar larvae. In order for establishment to occur, the pest would have to successfully develop to the late larval instar stage on imported greens discarded into the environment, then pupate in the soil, emerge as an adult, and find a suitable host plant to lay eggs. Although the likelihood of all these conditions being met is low, because hosts are widely available and *L. costirostris* exhibits parthenogenesis, we rated this risk element Medium. |
| Risk Element B2: Likelihood of arriving in the endangered area | Low | C | The populations of Puerto Rico (3,725,789) and the U.S. Virgin Islands (106,405) combined include less than 10 percent of the total U.S. population (U.S. Census Bureau, 2010). We assume that the commodity could potentially be shipped to Puerto Rico and the U.S. Virgin Islands on a year-round basis. |
| Risk Element B: Combined likelihood of establishment | Medium | N/A | |
| **Overall Likelihood of Introduction** | | | |
| Combined likelihoods of entry and establishment | Medium | N/A | |

[a]C=Certain, MC=Moderately Certain, MU=Moderately Uncertain, U=Uncertain

**Assessment of the consequences of introduction of *Listroderes costirostris* into Puerto Rico and the U.S. Virgin Islands (i.e., the PRA area)**

| Criteria | Meets criteria? (Y/N) | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Direct Impacts** | | | |
| Risk Element C1: Damage potential in the endangered area | Yes | C | One source claims damage by the weevil can cause a crop to be "badly injured, or totally destroyed for market purposes" (High, 1939). In 1933, estimated crop losses for tomatoes in Mississippi ranged from five percent to 70 percent (High, 1939), and in 1953, *Listroderes costirostris* severely damaged tobacco in South Carolina (Gentry, 1954). Entire fields of turnips, carrots, cabbages, mustard, and spinach have been destroyed by beetles in the early larval stages (High, 1939). More recent publications on crop losses were not found. |
| Risk Element C2: Spread potential | Yes | C | Originally from South America, this weevil has been spread to many new areas across the globe (Essig, 1933), including the continental United States (Bartlett et al., 1978; Clancy, 1969), Australia (Bartlett et al., 1978), Israel (Friedman, 2009), New Zealand (Bentancourt and Scatoni, 1999), South Africa (Bartlett et al., 1978), South Korea (ESK&KSAE, 1994), Spain (Morrone, 1993), and even distant locations such as Australia [Tasmania (Friedman, 2009)], Taiwan (Hsu and Chiang, 1983), Japan (Japan Plant Protection Association, 1987), and Chile [Easter Island (Friedman, 2009)]. In the southern United States, the weevil has spread at a rate of approximately 50 miles a year (High, 1939). In the state of Georgia, the weevil spread from seven counties to 112 counties within 15 years. It also spread into several additional states during that 15-year period (Beckham, 1953). In an area where the insect was present, turnip greens, radishes, and carrots ready for market were found infested with larvae (Beckham, 1953), indicating that spread to new areas via movement of commodities may readily occur. |
| Risk Element C: Pest introduction is likely to cause unacceptable direct impacts | Yes | N/A | |

| Criteria | Meets criteria? (Y/N) | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Conclusion** | | | |
| Is the pest likely to cause unacceptable consequences in the PRA area? | Yes | N/A | |

[a]C=Certain, MC=Moderately Certain, MU=Moderately Uncertain, U=Uncertain

3.2.2. *Lygus lineolaris*

We determined the overall likelihood of introduction of *Lygus lineolaris* to be Medium. We present the results of this assessment in the following table.

We determined that establishment of *Lygus lineolaris* in Hawaii, Puerto Rico, or the U.S. Virgin Islands is likely to cause unacceptable impacts. We present the results of this assessment in the following table.

**Determination of the portion of Hawaii, Puerto Rico, and the U.S. Virgin Islands endangered by *Lygus lineolaris***

| | |
|---|---|
| Climatic suitability | *Lygus lineolaris* is present in Bermuda (Henry and Hilburn, 1990), Canada (Kelton, 1980; Schwartz and Foottit, 1998), the continental United States (Schwartz and Foottit, 1998; Young, 1986), El Salvador (Schwartz and Foottit, 1998), Guatemala (Schwartz and Foottit, 1998), Honduras (Passoa, 1983; Schwartz and Foottit, 1998), and Mexico (McClay et al., 1995; Schwartz and Foottit, 1998).<br><br>These areas encompass Plant Hardiness Zones 2 through 13. Hawaii includes Plant Hardiness Zones 9 through 13, Puerto Rico 12 and 13, and the U.S. Virgin Islands Zone 13. Therefore, Hawaii, Puerto Rico, and the U.S. Virgin Islands include Plant Hardiness Zones that would be suitable for *Lygus lineolaris*. |
| Potential hosts at risk in PRA Area | *Lygus lineolaris* may feed on more taxa of plants than any other arthropod (Young, 1986). Host plants in the endangered area include pigweed (*Amaranthus* spp.), fleabane (*Erigeron* spp.), lambsquarters (*Chenopodium album*), mustard (*Brassica* spp.), narrowleaf plantain (*Plantago lanceolata*), common mullein (*Verbascum thapsus*), common bean (*Phaseolus vulgaris*), American black nightshade (*Solanum americanum*), silverleaf nightshade (*Solanum elaeagnifolium*), tomato (*Solanum lycopersicum*), and potato (*Solanum tuberosum*) (Kartesz, 2015; Young, 1986). |

| | |
|---|---|
| Economically important hosts at risk[a] | Because *L. lineolaris* is highly polyphagous, a large number of important agricultural and horticultural host plants could be at risk in Hawaii, Puerto Rico, and the U.S. Virgin Islands. *Lygus lineolaris* feeds on cabbage, cauliflower, cotton, green beans, lettuce, pepper, potato, soybean, and tomato (CABI, 2018a; Young, 1986). |
| Pest potential on economically important hosts at risk | *Lygus lineolaris* generally feeds on the buds, flowers, fruits, and seeds of plants (CABI, 2018a). In green beans, feeding by one adult insect on a flower bud raceme for three to five days can reduce the number of opening blossoms and bean pods (Khattat and Stewart, 1975). In soybeans, feeding by two to four *L. lineolaris* adults for a two-week period can reduce the number of soybean pods per node, the number of beans per pod, and the weight of the beans (Broersma and Luckmann, 1970). In lettuce, feeding by *L. lineolaris* can cause necrotic lesions on the ribs of the lettuce leaves, reducing marketability (Rekika et al., 2008). |
| **Defined Endangered Area** | The area endangered by *L. lineolaris* is any location in Hawaii, Puerto Rico, or the U.S. Virgin Islands where host plants occur. Hawaii includes Plant Hardiness Zones 9 through 13, Puerto Rico Zones 12 and 13, and the U.S. Virgin Islands Zone 13. *Lygus lineolaris* can inhabit these Plant Hardiness Zones where host plants occur. |

[a] As defined by ISPM No. 11, supplement 2, "economically-important hosts" refers to both commercial and non-market (environmental) plants (IPPC, 2017).

**Assessment of the likelihood of introduction of *Lygus lineolaris* into the endangered area via the importation of garland chrysanthemum from Mexico**

| Risk Element | Risk Rating | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Likelihood of Entry** | | | |
| Risk Element A1: Pest prevalence on the harvested commodity (= the baseline rating for entry) | Medium | MU | The preferred feeding sites for *Lygus lineolaris* are reproductive structures such as buds, flowers, fruits, and seeds (CABI, 2018a). This information is extrapolated to garland chrysanthemum. The commodity will be harvested 45 days prior to flowering (Golden-Fields, 2014); therefore, the preferred feeding sites will not be available to the insect. The Market Access Request, however, does state that *L. lineolaris* is also present later in the season during vegetative growth, is found on foliage, and can be associated with exported garland chrysanthemum greens (Trujillo-Arriaga, 2017). Therefore, we rated this risk element Medium instead of Low. |
| Risk Element A2: Likelihood of surviving post-harvest processing before shipment | Medium | C | *Lygus lineolaris* is not likely to increase or decrease in population size during the short period of time in which the commodity will be stored prior to shipment. Refrigeration prior to and during transport will slow the activity of the insects. After the harvesting process, screens will be used to protect the commodity from additional insects that may enter the crates (Golden-Fields, 2014). |
| Risk Element A3: Likelihood of surviving transport and storage conditions of the consignment | Medium | C | Refrigeration is the only treatment that occurs during the transport and storage of garland chrysanthemum (Golden-Fields, 2014). We found no evidence that this would change the insect population. |
| Risk Element A: Overall risk rating for likelihood of entry | Medium | N/A | |

| Risk Element | Risk Rating | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Likelihood of Establishment** | | | |
| Risk Element B1: Likelihood of coming into contact with host material in the endangered area | High | C | *Lygus lineolaris* can walk and fly (CABI, 2018a). It has a broad host range, and those hosts are widely distributed throughout the endangered area. |
| Risk Element B2: Likelihood of arriving in the endangered area | Low | C | The populations of Hawaii (1,360,301), Puerto Rico (3,725,789), and the U.S. Virgin Islands (106,405) combined include less than 10 percent of the total U.S. population (U.S. Census Bureau, 2010). |
| Risk Element B: Combined likelihood of establishment | Medium | N/A | |
| **Overall Likelihood of Introduction** | | | |
| Combined likelihoods of entry and establishment | Medium | N/A | |

[a]C=Certain, MC=Moderately Certain, MU=Moderately Uncertain, U=Uncertain

**Assessment of the consequences of introduction of *Lygus lineolaris* into Hawaii, Puerto Rico, and the U.S. Virgin Islands (i.e., the PRA area)**

| Criteria | Meets criteria? (Y/N) | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Direct Impacts** | | | |
| Risk Element C1: Damage potential in the endangered area | Yes | U | Soybeans, which are grown commercially in Puerto Rico (NASS, 2014b), could be at risk: feeding by two to four *L. lineolaris* adults for a two-week period can reduce the number of soybean pods per node, the number of beans per pod, and the weight of the beans (Broersma and Luckmann, 1970). Lettuce, grown commercially in both Puerto Rico and Hawaii (NASS, 2014a, 2014b), could also be at risk: feeding by *L. lineolaris* can cause necrotic lesions on the ribs of lettuce leaves, thus reducing marketability (Rekika et al., 2008). We increased the uncertainty rating because yield loss data for the crop species grown in Puerto Rico and Hawaii is not readily available. Most yield loss data on *L. lineolaris* is for cotton and strawberries (Bailey, 1986; Handley et al., 1993; Laster and Meredith, 1974; Mailloux and Bostanian, 1988; Parrott et al., 1985; Rhainds and English-Loeb, 2003; Rhainds et al., 2001; Wold and Hutchison, 2003), which are not grown in Hawaii or Puerto Rico (NASS, 2014a, 2014b). |
| Risk Element C2: Spread potential | Yes | MC | *Lygus lineolaris* has potential to spread, as it can fly (Blackmer et al., 2004). It is also highly polyphagous (Young, 1986) and therefore could readily find a suitable host. |

| Criteria | Meets criteria? (Y/N) | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| Risk Element C: Pest introduction is likely to cause unacceptable direct impacts | Yes | N/A | |
| **Conclusion** | | | |
| Is the pest likely to cause unacceptable consequences in the PRA area? | Yes | N/A | |

[a]C=Certain, MC=Moderately Certain, MU=Moderately Uncertain, U=Uncertain

3.2.3. *Maconellicoccus hirsutus*

We assessed the likelihood that the mealybug species *Maconellicoccus hirsutus* could be introduced into the United States via imported garland chrysanthemum from Mexico. We determined the overall likelihood of introduction to be Negligible. We present the results of this assessment as follows.

**Assessment of the likelihood of introduction of *Maconellicoccus hirsutus* into the endangered area via the importation of garland chrysanthemum from Mexico**

| Risk Element | Risk Rating | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Likelihood of Establishment** | | | |
| Risk Element B1: Likelihood of coming into contact with host material in the endangered area | Negligible | MC | See following explanation. |
| Risk Element B2: Likelihood of arriving in the endangered area | N/A | N/A | |
| Risk Element B: Combined likelihood of establishment | Negligible | N/A | |
| **Overall Likelihood of Introduction** | | | |
| Combined likelihoods of entry and establishment | Negligible | N/A | |

[a]C=Certain, MC=Moderately Certain, MU=Moderately Uncertain, U=Uncertain

**Life stage biology.** In general, female mealybugs typically go through four life stages after the egg stage, and some species, such as *Dysmicoccus brevipes*, bear live young (Ito, 1938). The first two nymphal instars are active and have longer legs than the adults. The third instar nymph has shortened legs and resembles the adult, which is much more sessile. Grasswitz and James (2008) studied movement of *Pseudococcus maritimus* nymphs and found that they rarely moved away from the points they were released. The farthest movement was 90 cm, but most distances were considerably shorter. Furthermore, no evidence indicated that mealybug movement was influenced by any cues other than surface features of the host. Cid et al. (2010) found that *Planococcus citri* nymphs hatched in bark crevices of grapevines and rarely moved into the green parts of vines unless populations were very large. Nymphs stopped moving upward when they encountered feeding locations in the bark and did not appear to move between plants via leaves or stems. In a study with three species of *Rastrococcus* mealybugs, *R. mangiferae*, *R. iceryoides*, and *R. invadens*, none of the *Rastrococcus* spp. migrated between trees, from trees to soil, or from trees to debris (Narasimham and Chacko, 1991). The crawlers of *Pseudococcus adonidum* (first and second instar nymphs) are very sensitive to desiccation (Browning, 1959). Furness (1976) hypothesized that low humidity was responsible for the high mortality seen in dispersing first instar nymphs of *Pseudococcus longispinus*. Browning (1959) also found high mortality in first and second instar nymphs in low humidity.

For mealybugs in general, the adult females are wingless and cannot disperse by flying. Females are often large, with bodies distorted by eggs or nymphs which they carry in their abdomens, although females of most species retain their legs and can move to some extent. Males, by contrast, develop wings and can fly as adults (McKenzie, 1967).

**Dispersal mechanisms.** Although they have limited ability to disperse by walking, mealybug nymphs may be carried away from hosts by wind. First and second instar nymphs of *Pseudococcus longispinus* were blown from pear trees onto sticky traps on warm, windy days (Barrass et al., 1994). Vitullo (2009) found the density of females on a plant influenced the number of nymphs blown onto the sticky traps. Also, dispersal by wind depends to a large extent on exposure to wind well off the ground, in the branches of the host plant (Barrass et al., 1994; Grasswitz and James, 2008). Crawlers on imported infested vegetables are highly unlikely to be in such environmental conditions, reducing the potential for aerial dispersal.

Dispersal by wind is dependent on the prevailing wind direction; nymphs have no control over where they are blown. This dispersal strategy relies on a very high number of nymphs, so that a few will arrive serendipitously on a suitable host. Commercial vegetables arriving in the United States are unlikely to carry high populations of gravid females. Crawlers would be unlikely to survive shipment, especially in chilled, low-humidity conditions. Some consumers of vegetables may dispose of inedible produce in outdoor compost bins, but since only a small number of vegetables are likely to be infested, mealybugs would only very rarely be moved into compost. Once in compost, the mealybugs would rarely be exposed to the kind of wind conditions necessary for dispersal. For these reasons, mealybugs arriving on commercial vegetables for consumption have a negligible likelihood of dispersing to find new hosts.

3.2.4. *Estigmene acrea*

We determined the overall likelihood of introduction of *Estigmene acrea* to be Low. We present the results of this assessment in the following table.

We determined that establishment of *Estigmene acrea* in Hawaii, Puerto Rico, or the U.S. Virgin Islands is likely to cause unacceptable impacts. We present the results of this assessment in the following table.

**Determination of the portion of Hawaii, Puerto Rico, and the U.S. Virgin Islands endangered by *Estigmene acrea***

| | |
|---|---|
| Climatic suitability | *Estigmene acrea* is present in Canada (Beadle and Leckie, 2012; Harry, 2005), Colombia (Capinera, 2008; Gallego and Velez, 1992), Costa Rica (McGuire and Crandall, 1967), Cuba (Heppner, 2003; Rieche Luis et al., 1996), El Salvador (McGuire and Crandall, 1967), Guatemala (Alvarado and Perez, 1991; Harry, 2005), Honduras (Harry, 2005), Nicaragua (MAG-FOR, 2004), Panama (McGuire and Crandall, 1967), and the continental United States (Beadle and Leckie, 2012).<br><br>These areas encompass Plant Hardiness Zones 3 through 13. Hawaii includes Plant Hardiness Zones 9 through 13, Puerto Rico 12 and 13, and the U.S. Virgin Islands Zone 13. Therefore, Hawaii, Puerto Rico, and the U.S. Virgin Islands are within Plant Hardiness Zones that would be suitable for *Estigmene acrea*. |
| Potential hosts at risk in PRA Area | Host plants available in Puerto Rico, Hawaii, and the U.S. Virgin Islands include spiny amaranth (*Amaranthus spinosus*), oleander (*Nerium oleander*), beach wormwood (*Artemisia stelleriana*), dogfennel (*Eupatorium capillifolium*), garden lettuce (*Lactuca sativa*), cabbage (*Brassica oleracea*), watermelon (*Citrullus lanatus*), corn (*Zea mays*), soybean (*Glycine max*), Java-bean (*Senna obtusifolia*), sweetclover (*Melilotus officinalis*), common bean (*Phaseolus vulgaris*), cowpea (*Vigna unguiculata*), tobacco (*Nicotiana tabacum*), cutleaf groundcherry (*Physalis angulate*), potato (*Solanum tuberosum*), and ramie (*Boehmeria nivea*) (Kartesz, 2015; Robinson et al., 2002). |
| Economically important hosts at risk[a] | Plants of economic importance at risk in Hawaii, Puerto Rico, and the U.S. Virgin Islands are lettuce, brassica, watermelon, corn, soybean, common bean, cowpea, tobacco, and potato (Kartesz, 2015; Robinson et al., 2002). |
| Pest potential on economically important hosts at risk | *Estigmene acrea* is not a consistent pest of crops, but it occasionally causes damage. In sugarbeet in California, severe damage by *Estigmene acrea* occurs every three to four years (Becker et al., 2016). In Sonora, Mexico, severe skeletonizing damage on corn leaves has killed corn plants in 1957 and 1958 (Sifuentes and Young, 1961). Soybeans from the same area saw a yield loss of 40 percent in due to *Estigmene acrea* in 1960 (Sifuentes and Young, 1961). |
| **Defined Endangered Area** | The area endangered by *Estigmene acrea* includes any location in Hawaii, Puerto Rico, or the U.S. Virgin Islands where host plants occur. Hawaii includes Plant Hardiness Zones 9-13, Puerto Rico Zones 12-13, and the U.S. Virgin Islands Zone 13. *Estigmene acrea* can inhabit these Plant Hardiness Zones where host plants occur. |

[a] As defined by ISPM No. 11, supplement 2, “economically important hosts” refers to both commercial and non-market (environmental) plants (IPPC, 2017).

**Assessment of the likelihood of introduction of *Estigmene acrea* into the endangered area via the importation of garland chrysanthemum from Mexico**

| Risk Element | Risk Rating | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Likelihood of Entry** | | | |
| Risk Element A1: Pest prevalence on the harvested commodity (= the baseline rating for entry) | Medium | MC | The market access request states that *Estigmene acrea* is present on the garland chrysanthemum crop throughout the growing season (Trujillo-Arriaga, 2017). The caterpillars feed on the foliage of crops (Trujillo-Arriaga, 2017; Becker et al., 2016; Young and Sifuentes, 1959) and can be associated with exported garland chrysanthemum greens (Trujillo-Arriaga, 2017). The caterpillars, however, are covered with long black hairs (Becker et al., 2016) and therefore may be detected and removed during harvest, which brings the risk rating from High down to Medium. |
| Risk Element A2: Likelihood of surviving post-harvest processing before shipment | Medium | C | The commodity will not be further handled after the harvesting process (Golden-Fields, 2014). Screens will be used to protect the harvested material from additional insects that may enter crates. The commodity will be refrigerated post-harvest, which will not affect the pest population. |
| Risk Element A3: Likelihood of surviving transport and storage conditions of the consignment | Medium | C | Refrigeration is the only treatment that occurs during the transport and storage of garland chrysanthemum (Golden-Fields, 2014). We found no evidence that this would change the insect population. |
| Risk Element A: Overall risk rating for likelihood of entry | Medium | N/A | |

| Risk Element | Risk Rating | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Likelihood of Establishment** | | | |
| Risk Element B1: Likelihood of coming into contact with host material in the endangered area | Low | MC | Pupae are found in leaf litter on the ground (Young and Sifuentes, 1959), and adult moths would presumably fly away during the harvest process. Only eggs (Rieche Luis et al., 1996) and caterpillars would likely be left on the commodity post-harvest. Caterpillars cannot fly and would not likely be able to travel far to find new hosts. In order for establishment to occur, the pest would have to successfully develop to the late larval instar stage on imported greens discarded into the environment, then pupate in the soil, emerge as an adult, and find a mate and a suitable host plant to lay eggs on. Considering the low likelihood of all these conditions being met, we rated this risk element Low. |
| Risk Element B2: Likelihood of arriving in the endangered area | Low | C | The populations of Hawaii (1,360,301), Puerto Rico (3,725,789), and the U.S. Virgin Islands (106,405) combined include less than 10 percent of the total United States population (U.S. Census Bureau, 2010). |
| Risk Element B: Combined likelihood of establishment | Low | N/A | |
| **Overall Likelihood of Introduction** | | | |
| Combined likelihoods of entry and establishment | Low | N/A | |

[a]C=Certain, MC=Moderately Certain, MU=Moderately Uncertain, U=Uncertain

**Assessment of the consequences of introduction of *Estigmene acrea* into Hawaii, Puerto Rico, and the U.S. Virgin Islands (i.e., the PRA area)**

| Criteria | Meets criteria? (Y/N) | Uncertainty Rating[a] | Justification for rating and explanation of uncertainty (and other notes as necessary) |
|---|---|---|---|
| **Direct Impacts** | | | |
| Risk Element C1: Damage potential in the endangered area | Yes | MC | Severe skeletonizing damage on leaves has been reported to kill corn plants in 1957 and 1958 (Sifuentes and Young, 1961). Losses of 40 percent were also reported in 1960 from soybeans in Sonora, Mexico (Sifuentes and Young, 1961). |
| Risk Element C2: Spread potential | Yes | MC | Caterpillars cannot fly and would not likely be able to travel far to find new hosts. Adults, however, can fly, and females will fly to seek a mate (Willis and Birch, 1982). |
| Risk Element C: Pest introduction is likely to cause unacceptable direct impacts | Yes | N/A | |
| **Conclusion** | | | |
| Is the pest likely to cause unacceptable consequences in the PRA area? | Yes | N/A | |

[a]C=Certain, MC=Moderately Certain, MU=Moderately Uncertain, U=Uncertain

3.2.5. '*Candidatus* Phytoplasma asteris'

This species is actionable only in Puerto Rico and U.S. Virgin Islands, so this analysis only concerns the importation of greens into Puerto Rico and U.S. Virgin Islands from Mexico.

We determined the overall likelihood of introduction of '*Candidatus* Phytoplasma asteris' to be Negligible. We present the results of this assessment in the following table.

Because the likelihood of introduction was negligible, we did not determine the endangered area, and we did not analyze the consequences of introduction or establishment.

**Assessment of the likelihood of introduction of '*Candidatus* Phytoplasma asteris' into the endangered area via the importation of garland chrysanthemum from Mexico**

| **Risk Element** | **Risk Rating** | **Uncertainty Rating**[a] | **Justification for rating and explanation of uncertainty (and other notes as necessary)** |
|---|---|---|---|
| **Likelihood of Entry** | | | |
| Risk Element A1: Pest prevalence on the harvested commodity (= the baseline rating for entry) | N/A | N/A | |
| Risk Element A2: Likelihood of surviving post-harvest processing before shipment | N/A | N/A | |
| Risk Element A3: Likelihood of surviving transport and storage conditions of the consignment | N/A | N/A | |
| Risk Element A: Overall risk rating for likelihood of entry | N/A | N/A | |
| **Likelihood of Establishment** | | | |
| Risk Element B1: Likelihood of coming into contact with host material in the endangered area | Negligible | C | This species of phytoplasma is vectored by insects that are not known to occur in Puerto Rico and the Virgin Islands. The vectors are not likely to feed on wilted or discarded greens (CABI, 2018a). The likelihood that '*Candidatus* Phytoplasma asteris' will be able to move from the infected greens to new hosts in the import area is negligible. |
| Risk Element B2: Likelihood of arriving in the endangered area | N/A | N/A | |
| Risk Element B: Combined likelihood of establishment | N/A | N/A | |
| **Overall Likelihood of Introduction** | | | |
| Combined likelihoods of entry and establishment | Negligible | N/A | |

[a]C=Certain, MC=Moderately Certain, MU=Moderately Uncertain, U=Uncertain

# 4. Summary and Conclusions of Risk Assessment

Of the organisms associated with garland chrysanthemum worldwide and present in Mexico, we identified those that are actionable pests for the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands, and have a reasonable likelihood of being associated with the commodity following harvesting from the field and prior to any post-harvest processing. If warranted, we further evaluated these organisms for their likelihood of introduction (i.e., entry plus establishment) and their potential consequences of introduction. Pests that are likely to cause unacceptable consequences of introduction with an overall likelihood of introduction risk rating above Negligible 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. For this risk assessment, the specific pathway of concern is the importation of the fresh leafy greens of garland chrysanthemum, *Glebionis coronarium* (L.) Tzvelev, for consumption from Mexico into the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands. Hand-harvesting, exclusion of pests with screens, and refrigeration were the only procedures considered that may affect pests on the commodity.

Of the pests selected for further analysis, we determined that those identified in Table 3 are not candidates for risk management because they received a Negligible risk rating for likelihood of introduction into the endangered area via the import pathway. We summarize the results for each pest in Table 3.

All the other pests selected for further analysis are candidates for risk management because they are likely to cause unacceptable consequences of introduction, and they received a likelihood of introduction risk rating above Negligible. We summarize the results for each pest in Table 4.

Detailed examination and choice of appropriate phytosanitary measures to mitigate pest risk are part of the pest risk management phase within APHIS and are not addressed in this document.

**Table 3.** Summary for pests selected for further evaluation and determined not to be candidates for risk management.

| Pest | Reason the pest is *not* a candidate for risk management | Uncertainty statement (optional)[a] |
|---|---|---|
| *Maconellicoccus hirsutus* | Negligible likelihood of introduction | |
| '*Candidatus* Phytoplasma asteris' | Negligible likelihood of introduction | |

[a]The uncertainty statement, if included, identifies the most important source(s) of uncertainty.

**Table 4**. Summary for 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.

| Pest | Likelihood of Introduction overall rating | Uncertainty statement (optional)[a] |
|---|---|---|
| *Listroderes costirostris* | Medium | |

| Pest | Likelihood of Introduction overall rating | Uncertainty statement (optional)[a] |
|---|---|---|
| *Lygus lineolaris* | Medium | |
| *Estigmene acrea* | Low | |

[a]The uncertainty statement, if included, identifies the most important source(s) of uncertainty.

## 5. Acknowledgements

**Authors** Wendy Marchant, Risk Analyst/Entomologist[a]
Maria Acevedo-Sanchez, Risk Analyst/Plant Pathologist[a]

**Reviewers** Leah Millar, Risk Analyst/Entomologist[a]
Heather Hartzog, Risk Analyst/Plant Pathologist[a]

[a] Plant Epidemiology and Risk Analysis Laboratory, USDA-APHIS-PPQ

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## 7. Appendix: Pests with non-actionable regulatory status

We found some evidence of the listed organisms being associated with garland chrysanthemum, *Glebionis coronarium*, and being present in Mexico. Because these organisms have non-actionable regulatory status for the entire United States, including Hawaii, Puerto Rico, and the U.S. Virgin Islands, however, we did not list them in Table 1 of this risk assessment, and we did not evaluate the strength of the evidence for their association with garland chrysanthemum or their presence in Mexico. 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 Mexico.

We list these organisms along with the references supporting their potential association with garland chrysanthemum, their potential presence in Mexico, their presence in the United States (if applicable), and their regulatory status for the United States. For organisms not present in the United States, we also provide justification for their non-actionable status.

| Organism | Evidence and/or other notes |
|---|---|
| **ACARI** | |
| **Tetranychidae** | |
| *Tetranychus urticae* Koch | Bolland et al., 1998<br><br>Present in the continental United States, Hawaii, and Puerto Rico (Bolland et al., 1998). |
| **INSECTA** | |
| **DIPTERA** | |
| **Agromyzidae** | |
| *Liriomyza sativae* Blanchard | Medina et al., 2014; Chen et al., 2003; Tokumaru and Abe, 2005; Tran, 2009<br><br>Present in the continental United States (Spencer and Steyskal, 1986), Hawaii (Carolina et al., 1992), Puerto Rico (Martorell, 1976), and the U.S. Virgin Islands (Insectoid, 2018). |
| *Liriomyza trifolii (Burgess)* | Tanaka et al., 2000; Tokumaru and Abe, 2005; Trujillo-Arriaga, 2017; Zhao et al., 2015<br><br>Present in the continental United States (Spencer and Steyskal, 1986), Hawaii (Hara, 1986), Puerto Rico (Cabrera-Asencio and Vélez, 2006), and the U.S. Virgin Islands (CABI, 2018a). |
| **HEMIPTERA** | |
| **Aleyrodidae** | |

| **Organism** | **Evidence and/or other notes** |
|---|---|
| *Bemisia tabaci* (Gennadius) | Takeuchi et al., 1994; Trujillo-Arriaga, 2017<br><br>Present in the continental United States (CABI, 2018a), Hawaii (Omer et al., 1993), Puerto Rico (Martorell, 1976), and the U.S. Virgin Islands (UVI, 2018). |
| **Aphididae** | |
| *Aphis gossypii* Glover | CABI, 2018a; Martorell, 1976; Messing and Klungness, 2001; Trujillo-Arriaga, 2017; VIAES, 1920<br><br>Present in the continental United States (CABI, 2018a), Hawaii (Messing and Klungness, 2001), Puerto Rico (Martorell, 1976), and the U.S. Virgin Islands (VIAES, 1920). |
| *Brachycaudus helichrysi* (Kaltenbach) | Many interceptions from permit cargo from Mexico in PestID (PestID, 2018); Kavallieratos et al., 2006; Kavallieratos et al., 2007<br><br>Present in the continental United States (Halbert et al., 2000), Hawaii (Nishida, 2002), and Puerto Rico (Martorell, 1976). |
| *Myzus persicae* (Sulzer) | Trujillo-Arriaga, 2017<br><br>Present in the continental United States (Stoetzel and Miller, 1998), Hawaii (Toba, 1964), and Puerto Rico (Martorell, 1976). |
| **Diaspididae** | |
| *Aspidiotus nerii* Bouche | Hall, 1923; Nakahara, 1982<br><br>Present in the continental United States (Miller, 2005), Hawaii (Nakahara, 1981), and Puerto Rico (Martorell, 1976; Miller, 2005; Nakahara, 1982). |
| *Hemiberlesia lataniae* (Signoret) | Hall, 1923; Rugman-Jones et al., 2009<br><br>Present in the continental United States (Miller, 2005), Hawaii (Nakahara, 1981), Puerto Rico (Martorell, 1976; Miller, 2005), and the U.S. Virgin Islands (Nakahara, 1983). |
| **Margarodidae** | |
| *Icerya purchasi* Maskell | Hall, 1923; CABI, 2018a<br><br>Present in the continental United States (CABI, 2018a), Hawaii (Hale, 1970), Puerto Rico (Martorell, 1976), and the U.S. Virgin Islands (Nakahara, 1983). |
| **LEPIDOPTERA** | |
| **Noctuidae** | |

| Organism | Evidence and/or other notes |
|---|---|
| *Spodoptera exigua* (Hübner) | Trujillo-Arriaga, 2017<br><br>Present in the continental United States (Greenberg et al., 2001), Hawaii (Funasaki et al., 1988), and Puerto Rico (Armstrong, 1994; Ruiz and Gallardo Covas, 1985). |
| *Trichoplusia ni* (Hübner) | Trujillo-Arriaga, 2017<br><br>Present in the continental United States (CABI, 2018a), Hawaii (Nishida, 2002), Puerto Rico (Martorell, 1976), and the U.S. Virgin Islands (Arnaud, 1978). |
| **THYSANOPTERA** | |
| **Thripidae** | |
| *Caliothrips fasciatus* (Pergande) | Trujillo-Arriaga, 2017<br><br>Present in the continental United States (Rugman-Jones et al., 2012), Hawaii (Mound et al., 2016), and Puerto Rico (Martorell, 1976). |
| *Frankliniella occidentalis* (Pergande) | Trujillo-Arriaga, 2017; Marullo, 2002<br><br>Present in the continental United States (Kirk and Terry, 2003; Rugman-Jones et al., 2012), Hawaii (Mound et al., 2016), and Puerto Rico (Feliciano et al., 2008; Martorell, 1976). |
| **NEMATODES** | |
| *Meloidogyne arenaria* (Neal, 1889) Chitwood, 1949 | Mexico and continental United States (CABI, 2018b; Rich et al., 2008); Hawaii and Puerto Rico (CABI, 2018b); Non-reportable (PestID, 2018) |
| *Pratylenchus brachyurus* (Godfrey, 1929) Filipjev & Schuurmans Stekhoven | Mexico, continental United States, Hawaii and Puerto Rico (CABI, 2018a); Non-reportable (PestID, 2018) |
| **FUNGI** | |
| *Alternaria chrysanthemi* E.G. simmons & Crosier, 1965, syn.: *Alternaria leucanthemi* | Mexico (SENASICA, 2017); continental United States (Farr and Rossman, 2018); Non-reportable (PestID, 2018) |
| *Ascochyta chrysanthemi* F. Stevens, 1907, syn.: *Phoma ligulicola* Boerema 1990 | Mexico (SENASICA, 2017); continental United States (Farr and Rossman, 2018); Non-reportable (PestID, 2018) |
| *Golovinomyces cichoracearum* (DC.) V.P. Heluta | Mexico, continental United States, Hawaii, Puerto Rico and United States Virgin Islands (CABI, 2018a); Non-reportable (PestID, 2018) |
| *Thanatephorus cucumeris* (A. B. Frank) Donk, 1956 | Mexico (Montero-Tavera et al., 2007); continental United States, Hawaii and Puerto Rico (CABI, 2018a; Farr and Rossman, 2018); Non-reportable (PestID, 2018) |
| **BACTERIA** | |

| Organism | Evidence and/or other notes |
|---|---|
| *Agrobacterium tumefaciens* (Smith & Townsend) Conn | Mexico and continental United States (Bradbury, 1986; CABI, 2018a); Hawaii and Puerto Rico (CABI, 2018a); Non-reportable (PestID, 2018) |
| *Pseudomonas cichorii* (Swingle) Stapp 1928 | Mexico (CABI, 2018b); continental United States (Bradbury, 1986); Hawaii and Puerto Rico (CABI, 2018a) |