Importation of Fresh Guava Fruit, *Psidium guajava*, from Taiwan into the Continental United States

A Qualitative, Pathway-Initiated Pest Risk Assessment

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Version 3

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Executive Summary

The Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA) prepared this document to examine plant pest risks associated with the movement of fruit of fresh guava, *Psidium guajava* L., from Taiwan into the continental United States. In preparing this assessment, we assumed that minimal post-harvest processing would occur, including pre-cooling fruit, and manual or mechanical grading by size and weight. We developed a list of pests reported in Taiwan that attack guava based on the scientific literature, port-of-entry pest interception data, and information provided by the government of Taiwan. From the pest list, we identified 24 quarantine pests as likely to follow the commodity pathway of fresh guava fruit from Taiwan and that are candidates for risk mitigation.

Type	Taxonomy	Pest Scientific Name
Arthropods	Acari: Tetranychidae	*Eutetranychus orientalis*
		Oligonychus biharensis
		Oligonychus litchi
	Diptera: Tephritidae	*B. cucurbitae; B. dorsalis; B. tau*
	Hemiptera: Coccidae	*Ceroplastes rubens*
		Drepanococcus cajani, D. chiton
		Taiwansaissetia formicarii
		Vinsonia stellifera
	Hemiptera: Margarodidae	*Icerya aegyptiaca; I. seychellarum*
	Hemiptera: Pseudococcidae	*Exallomochlus camur*
		Maconellicoccus hirsutus
		Nipaecoccus viridis
		Planococcus lilacinus
		Pseudococcus cryptus
		Rastrococcus spinosus
	Lepidoptera: Noctuidae	*Helicoverpa armigera*
	Lepidoptera: Pyralidae	*Conogethes punctiferalis*
	Thysanoptera: Thripidae	*Rhipiphorothrips cruentatus*
Fungi		*Pestalotiopsis psidii*

All of these pests pose phytosanitary risks to U.S. agriculture. We estimated the Pest Risk Potential to be High for *B. cucurbitae*, *B. dorsalis*, *B. tau*, *Conogethes punctiferalis*, and *Helicoverpa armigera;* and Medium for all other pests.

The choice of appropriate measures to mitigate risks is not addressed within this risk assessment 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), in response to a request to evaluate the risks associated with the importation of commercially produced fresh fruit of guava from Taiwan into the continental United States.

The International Plant Protection Convention (IPPC) provides guidance for conducting pest risk analyses. The methods used here are consistent with guidelines provided by the IPPC, specifically the International Standard for Phytosanitary Measures (ISPM) on ‘Pest Risk Analysis for Quarantine Pests, Including Analysis of Environmental Risks and Living Modified Organisms’ (IPPC, 2009: ISPM #11). The use of biological and phytosanitary terms is consistent with the ‘Glossary of Phytosanitary Terms and the Compendium of Phytosanitary Terms’ (IPPC, 2009: ISPM #5).

Three stages of pest risk analysis are described in international standards: Stage 1, Initiation, Stage 2, Risk Assessment, and Stage 3, Risk Management. This document satisfies the requirements of Stages 1 and 2.

This is a qualitative risk analysis; estimates of risk are expressed in terms of High, Medium, and Low pest risk potentials based on the combined ratings for specified risk elements (PPQ, 2000) related to the probability and consequences of importing this guava commodity from Taiwan. For the purposes of this assessment High, Medium, and Low probabilities will be defined as:

High: More likely to occur than not to occur
Medium: As likely to occur as not to occur
Low: More likely to not occur than to occur

The appropriate risk management strategy for a particular pest depends on the risk posed by that pest. Identification of appropriate sanitary and phytosanitary measures to mitigate the risk, if any, for this pest is undertaken as part of Stage 3 (Risk Management).

1.2. Description of the Commodity

Guava, *Psidium guajava* L., is a fruit tree in the Myrtle family (Myrtaceae) that originates from tropical America. In Taiwan it can flower year round, but in general there are two fruiting periods: April through July (summer fruit) and September through November (winter fruit). The winter fruit is generally recognized to be of higher quality in terms of fragrance and texture (BAPHIQ, 2011).

Guava fruit are typically 5-10 cm long and may be round, ovoid, or pear-shaped, with 4 or 5 sepals at the apex (REF). The fleshy part of the fruit is typically thick and crispy, and covered by a thin, semi-rough skin. The central pulp is juicy and normally filled with very hard seeds that are about 1/8 inch long, although some varieties have soft, chewable seeds. Actual seed counts vary by the cultivar, and range from 112 to 535, although some varieties are seedless or nearly so (Morton, 1987).

Several cultivars of guava are grown in Taiwan, including Twenty Century, Pearl, and Crystal. Some varieties (e.g., Crystal) may be more susceptible to various fruit rots and other pests and require additional management (BAPIQ, 2009). However, because the market access request is for all varieties of *P. guajava*, in this risk assessment we did not distinguish between different varieties of guava in terms of pest risk.

1.3. Standard Production Practices and Post-Harvest Processing

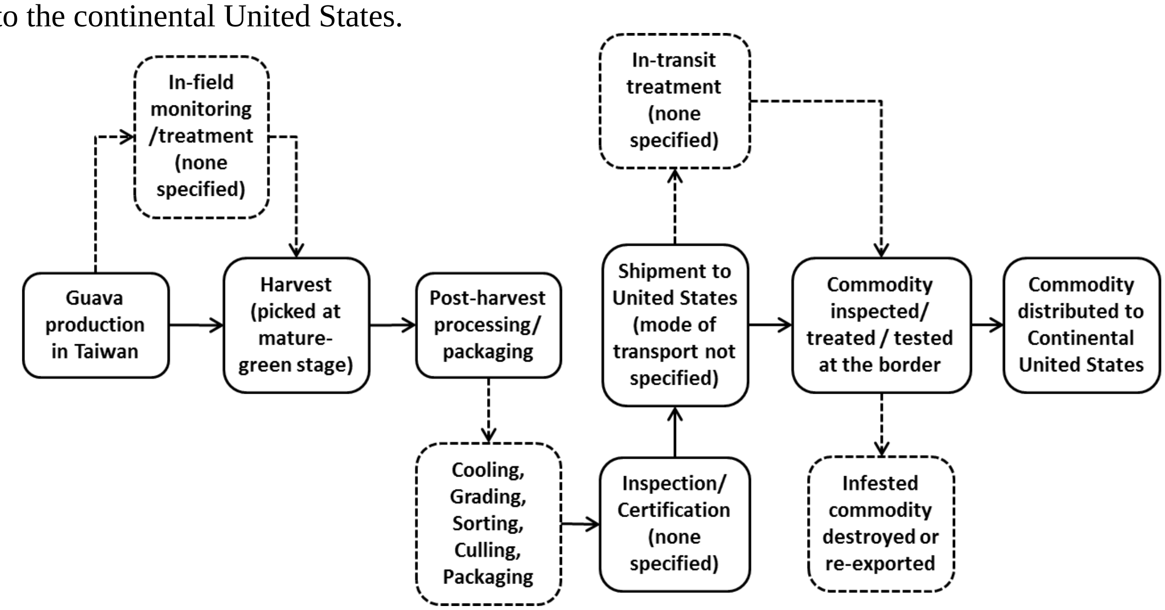
Guava fruit is picked at the mature-green stage in the early morning when the temperature is cool (BAPHIQ, 2011). Care is taken to avoid exposing the fruit to direct sunlight and physical damage during harvesting and handling.

Picked guava fruit are moved to the packinghouse for pre-cooling and manual or mechanical grading by size and weight. Prior to pre-cooling, the fruit peduncle is trimmed. After fruit are pre-cooled, they are graded. During the selection process, infected, disordered, discolored, or decayed fruit are removed. Selected fruit are placed in clean plastic bags and fruit nets, and are then packed into boxes or cartons marked with the brand logo of the grower and the variety, quality, and size (BAPHIQ, 2011).

Specific shipping and storage conditions were not specified. In general, fruit to be exported from Taiwan is loaded into a refrigerated container for disinfestation treatment or transportation, based on the quarantine requirements of the importing country.

Below we graphically summarized the pathway of concern (Fig. 1).

Figure 1. Pathway for the importation of fresh guava fruit (*Psidium guajava* L.) from Taiwan into the continental United States.



2. Risk Assessment

2.1. Initiating Event: Proposed Action

We prepared this commodity-based, pathway-initiated pest risk assessment in response to a request for the USDA's authorization to allow the importation of fresh guava fruit from Taiwan into the continental United States (Ko, 2009). The movement of fruits and vegetables from foreign countries, such as Taiwan, into the United States is regulated in 7 CFR §319.56 (2011). Currently, the entry of fresh guava fruit from Taiwan into the continental United States is not authorized under 7 CFR §319.56; the government of Taiwan seeks a change in this Federal Regulation to allow entry.

2.2. Assessment of the Weed Potential of Guava

If the species considered for import poses a risk as a weed pest, then a "pest-initiated" risk assessment is conducted. The results of the weed potential screening for guava did not prompt a pest-initiated risk assessment (Table 1).

Table 1. Assessment of weed potential of guava.

Commodity scientific name: *Psidium guajava* Linnaeus [Myrtaceae] **Common name:** Goyaveiro, Goyavier, Guava, Guave, Guavenbaumb, Guayaba, Lemon guava (Wiersema and Leon, 1999)	
Phase 1: Distribution in the United States *Psidium guajava* is distributed in the following States or territories in the United States: Louisiana, Florida, Hawaii, Puerto Rico, Virgin Islands (Kartesz, 2010; NRCS, 2011), Arizona (Kartesz, 2010), and California (Morton, 1987).	
Phase 2: Invasive / Weed Status: Listing as Weed	
The species is listed in:	
YES	Geographical Atlas of World Weeds (Holm et al., 1991a)
NO	World's Worst Weeds (Holm et al., 1991b)
NO	World Weeds: Natural Histories and Distribution (Holm et al., 1997)
NO	Weed Science Society of America (WSSA, 2010)
NO	Federal Noxious Weed List (PPQ, 2010)
NO	Economically Important Foreign Weeds (Reid, 1977)
NO	Identification of disseminules listed in the Federal Noxious Weed Act (Gunn and Ritchie, 1988)
NO	Global Invasive Species Database (ISSG, 2010)
YES	A Global Compendium of Weeds (Randall, 2010)
YES	Invasive Species of the World (Weber, 2003)
YES	Invasive Plant Atlas of the United States (CISEH, 2011)
NO	Noxious weeds in the United States and Canada (Rice, 2010)
YES	State Noxious Weeds. Invasive and Noxious weeds (NRCS, 2011)
Other: Scientific literature, Internet sources, etc.:	
NO	AGRICOLA (NAL, 2011), AGRIS (FAO, 2011)
YES	CABI (CABI, 2011)

YES	Florida's Invasive Species List, Florida Exotic Pest Plant Council (FLEPPC, 2009)
YES	Pacific Island Ecosystems at Risk (Forest Service, 2010)
NO	Noxious weed list for Australian states and territories (Australian Weeds Committee, 2010)

Phase 3: Summary and Conclusions

Guava is present in Louisiana, Florida, Hawaii, Puerto Rico, the Virgin Islands (Kartesz, 2010; NRCS, 2011), Arizona (Kartesz, 2010), and California (Morton, 1987). Specific information referring to guava as a weed, with specific patterns of invasion, is described for several worldwide distributed environments, with more impact in the Pacific Islands (CISEH, 2011; Forest Service, 2010; Morton, 1987; Randall, 2010; Weber, 2003). Guava is included in the list of invasive species in the State of Florida and is distributed in the central and southern region of this State (FLEPPC, 2009). However, Holm et al. (1991a) list it as a weed of unknown importance in the United States.

Conclusion: We proceeded with the commodity pathway-initiated pest risk assessment because guava is naturalized in the continental United States and is grown as a crop in Florida (CIPM, 2011). Because guava is already is established in the continental United States, the importation of fresh fruit from Taiwan should not increase the plant's weed potential beyond that existing at present. A pest-initiated pest risk assessment, therefore, is not necessary.

2.3. Current Status

As stated above, the entry of fresh guava fruit from Taiwan into the United States is currently not authorized under 7 CFR §319. Guava fruit for consumption may enter the continental United from Hawaii, Mexico, and Bermuda (Table 2); entry is not authorized from any other countries or territories (APHIS, 2012a; PPQ, 2011a, 2011b, 2011c) (query made February 15, 2011).

Table 2. Countries or regions from which guava fruit are permitted entry into the continental United States

Country or Region	**Requirement for Entry**
Mexico	1) Commercial consignments only; 2) subject to inspection at the port-of-entry and all general requirements of 7 CFR §319.56-3; 3) phytosanitary certificate with an additional declaration stating that "[t]he fruit in this consignment was treated by irradiation with a minimum absorbed dose of 400 Gy and inspected and found free of *Oligonychus biharensis, Oligonychus psidium, Mycovellosiella psidii, Pestalotiopsis psidii, and Sphaceloma psidii*"; 4) have the palletized cartons wrapped with polyethylene shrink wrap, net wrapping, or strapping (for consignments in sea containers only; not required for air shipments because integrity is maintained by the container itself).
Hawaii	1) Commercial consignments only, 2) 400 Gy irradiation treatment (T105-a-2), 3) each shipment must be inspected in Hawaii and found free of the red spider mite (*Eutetranychus orientalis*) and the cassava red mite (*Oligonychus biharensis*).

Bermuda	Subject to inspection at the port-of-entry and all general requirements of 7 CFR §319.56-3.

2.4. Pest Categorization

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

The following pests have all been intercepted on guava at least once at U.S. ports of entry: *Aeoloderma brachmana* (Candeze), *Corcyra cephalonica* (Stainton), *Diaphania indica* (Saunders), *Maruca vitrata* (Fabricius), *Parlatoria proteus* (Curtis), *Pectinophora gossypiella* Saunders, *Peregrinus maidis* (Ashmead), *Planococcus angkorensis* (Takahashi) [Syn: *P. dorsopinus* Ezzat & McConnell), and *Thrips palmi* Karny (PestID, 2012). In each case, however, we were unable to find substantiating evidence that guava is a host of the pest. Therefore, because each of these pests was intercepted fewer than three times, and because the interceptions generally occurred in passenger baggage, we consider these interception records to be insufficient evidence of a host association.

The British Natural History Museum's HOSTS database (Robinson et. al, 2007) is one of the most comprehensive compilations of Lepidopteran host plant data available; however, as noted by the authors, there are many potential sources of error in the database, including misidentifications, transcription mistakes, confusion between similar plant names, etc. Additionally, HOSTS does not report the status of individual records (e.g., whether they are considered true, erroneous or suspect). For this reason, we only consider HOSTS to be sufficient evidence of a particular pest/host association (in and of itself) when there are multiple records of that association in the database. For each of the following pests, only one record existed in HOSTS of the pest on guava: *Agrotis ipsilon* (Hufnagel), *Phomopsis mangiferae* S. Ahmed, *Monilinia fructicola* (G. Winter) Honey, *Suastus gremius* Faricius, and *Orgyia postica* (Walker) [Syn: *Notolophus asutralis posticus* Walker]. Because we were unable to find substantiating evidence of host association with guava, we consider the host association with guava to be dubious.

Bactrocera latifrons (Hendel) is listed as a "doubtful" pest of guava by White and Elson-Harris (1994) and a comprehensive review of the host plants of *B. latifrons* (Liquido et al., 1994) states that reports of guava as a host in the literature are erroneous.

We found only one reference indicating that *Bactrocera pedestris* (Bezzi) is present in Taiwan (see Hua, 2005). Other references indicate it is only known to be distributed in the Philippines (e.g., Drew and Hancock, 1994; Carroll et al., 2002). Additionally, we found no primary references indicating that *B. pedestris* attacks guava. Although it is listed as being associated with guava in both Gould and Raga (2002) and Yunus and Ho (1980), neither source provides any supporting references or citations to indicate why the authors included the organism on their respective lists. Therefore, because *B. pedistris* is often confused with *B. dorsalis* (Armstrong and Couey, 1989; Drew et al., 1979)—a pest that commonly occurs on guava in Taiwan (BAPHIQ, 2011)—we do not think there is sufficient evidence to include *B. pedistris* on this pest list.

Bactrocera caudata has been listed by several sources to be present in Taiwan (e.g., Gould and Raga, 2002; Kapoor, 2005; White and Elson-Harris, 1994) but we found no primary references for its presence there. Previous records may have been a misidentification of *B. tau*. Therefore, we do not have sufficient evidence to include this pest on the pest list.

2.4.2 Pest associated with guava

Below we list the pests associated with guava (in any country) that occur in Taiwan (Table 3). This list identifies (1) the presence or absence of these pests in the United States, (2) the generally affected plant part or parts, (3) the quarantine status of the pest with respect to the United States, (4) whether the pest is likely to follow the pathway and enter the United States on commercially exported guava fruit with stem, and (5) pertinent citations for either the distribution or the biology of the pest. In light of pest biology and distribution, many organisms are eliminated from further consideration as sources of phytosanitary risk on guava from Taiwan because they do not satisfy the definition of a quarantine pest.

Table 3. Pests associated with guava, *Psidium guajava*, that are also present in Taiwan.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
ARTHROPODS					
Acari: Tarsonemidae					
Polyphagotarsonemus latus (Banks)	Taiwan (CABI, 2011); US (Commonwealth Institute of Entomology, 1986)	Crop Knowledge Master, 2006	No	N/A	N/A
Acari: Tenuipalpidae					
Brevipalpus californicus (Banks)	US (HI) (CABI, 2011), (CONUS) (CABI, 2011)	CABI, 2011; Gould and Raga, 2002; Morton, 1987	No	N/A	N/A
Brevipalpus phoenicis (Geijskes)	Taiwan (Jeppson et al., 1975); US (CABI, 2011; Jeppson et al., 1975)	BAPHIQ, 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; Mitchell, 1973; Morton, 1987; Jeppson et al., 1975	No	N/A	N/A

[1] Geographic Distribution: HI = Hawaii, CONUS = continental United States, AL = Alabama, AZ = Arizona, CA = California, FL = Florida, GA = Georgia, MT = Montana, NC = North Carolina, NV = Nevada, TX = Texas (Individual U.S. states are listed only if the pest species is considered a quarantine pest for the continental United States.)

[2] Brackets around the quarantine status designation indicate that the pest has a limited distribution in the continental United States and is either under official control or under consideration for official control.

[3] For the non-quarantine pests in this table, we put N/A (= Not Applicable) in the columns for "Plant Part(s) Association" and "Likely to Follow Pathway." See discussion above for more information.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Acari: Tetranychidae					
Eotetranychus sexmaculatus (Riley)	Taiwan (Bolland et al., 1998); US (Bolland et al., 1998)	Bolland et al., 1998; Migeon and Dorkeld, 2006; Mitchell, 1973	No	N/A	N/A
Eutetranychus orientalis (Klein)	Taiwan (CABI, 2011); US (HI) (Heu, 2007)	Bolland et al., 1998; CABI, 2011; Gould and Raga, 2002	Yes	Leaves, fruit (Avidov and Harpaz, 1969; Childers, n.d.; Dhooria and Butani, 1984; van den Berg et al., 2001)	Yes
Oligonychus biharensis (Hirst) (Syn: *Paratetranychus hawaiiensis* McGregor)	Taiwan (Bolland et al., 1998); US (HI) (Bolland et al., 1998)	Bolland et al., 1998; Gould and Raga, 2002; Migeon and Dorkeld, 2006	Yes	Leaves (CABI, 2011; Gould and Raga, 2002; Kwee and Chong, 1990); fruit (Gould and Raga, 2002)	Yes
Oligonychus coffeae (Nietner)	Taiwan (Bolland et al., 1998; Jeppson et al., 1975); US (Bolland et al., 1998; CABI, 2011)	Bolland et al., 1998; Migeon and Dorkeld, 2006	No	N/A	N/A
Oligonychus litchi Lo & Ho	Taiwan (Bolland et al., 1998)	Bolland et al., 1998	Yes	Leaves, fruit[4]	Yes
Oligonychus mangiferus (Rahman & Sapra)	Taiwan (Bolland et al., 1998); US (HI) (Bolland et al., 1998; Jeppson et al., 1975)	Bolland et al., 1998; Migeon and Dorkeld, 2006	Yes	Leaves (Jeppson et al., 1975)	No
Panonychus citri (McGregor)	Taiwan (Bolland et al., 1998; ChyiChen, 2000); US (Bolland et al., 1998; CABI, 2011)	Migeon and Dorkeld, 2006	No	N/A	N/A
Tetranychus neocaledonicus André	Taiwan (Bolland et al., 1998); US (Bolland et al., 1998)	Bolland et al., 1998; Migeon and Dorkeld, 2006	No	N/A	N/A

[4] Based on biology of *Oligonychus biharensis.*

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Tetranychus truncatus Ehara	Taiwan (Bolland et al., 1998; CABI, 2011)	Bolland et al., 1998	Yes	Leaves, stems, branches, bark (CABI, 2011)	No
Tetranychus urticae Koch (Syn: *T. cinnabarinus* (Boisd.))	Taiwan (CABI, 2011); US (Bolland et al., 1998; CABI, 2011)	Bolland et al., 1998; Migeon and Dorkeld, 2006	No	N/A	N/A
Coleoptera: Bostrichidae					
Heterobostrychus aequalis Waterhouse	Taiwan (Hua, 2002); US (CABI, 2011)	EPPO, 2007	No	N/A	N/A
Sinoxylon anale (Lesne)	Taiwan (Hua, 2002)	EPPO, 2007	No[5]	N/A	N/A
Xylopsocus capucinus Fabricius	Taiwan (Hua, 2002); US (Woodruff et al., 2005)	Woodruff et al., 2005	No	N/A	N/A
Coleoptera: Cerambycidae					
Anoplophora chinensis (Forster)	Taiwan (CABI, 2011)	CABI, 2011	Yes	Stems, shoots, trunk, branches, leaves, roots, bark (CABI, 2011)	No
Coleoptera: Curculionidae					
Hypomeces squamosus (Fabricius)	Taiwan (CABI, 2011)	Gould and Raga, 2002; Hill, 1983; Waterhouse, 1993	Yes	Leaves (CABI, 2011; Hill, 2008; Waterhouse, 1993)	No
Coleoptera: Scarabaeidae					
Adoretus sinicus Burmeister (Syn: *A. tenuimaculatus* Waterhouse)	Taiwan (Commonwealth Institute of Entomology, 1986; Hua, 2002; Mau and Kessing, 1991); US (HI) (Mau and Kessing, 1991; Mitchell, 1973)	HDOA, 2008; Mitchell, 1973	Yes	Larvae: Soil, leaves litter, compost (HDOA, 2008); Adults: Leaves (Hill, 1983; Wen et al., 2002)	No

[5] *Sinoxylon anale* is a non-quarantine pest for the continental United States because most beetles in this family do not cause problems on live plants in temperate areas (PestID, 2012)

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Coleoptera: Scolytidae					
Euwallacea fornicatus (Eichhoff) (Syn: *Xyleborus fornicatus* Eichhoff)	Taiwan (CABI, 2011); US (HI) (CABI, 2011)	CABI, 2011	Yes	Bark, trunk, wood (CABI, 2011); trunk, branches, fruits, seeds (Wang and Yuan, 2003)	No[6]
Diptera: Tephritidae					
Bactrocera cucurbitae (Coquillett) (Syn: *Dacus cucurbitae* Coquillett)	Taiwan (CABI, 2011); US (HI) (CABI, 2011; Gould and Raga, 2002)	CABI, 2011; Gould and Raga, 2002; Hill, 1983; Morton, 1987; PPQ, 2002; Mitra and Bose, 2001	Yes	Fruit, flowers, roots, leaves, stems (CABI, 2011; PPQ, 2002)	Yes
Bactrocera dorsalis (Hendel)	Taiwan (BAPHIQ, 2011); US (HI) (CABI, 2011; Gould and Raga, 2002)	BAPHIQ, 2011; Gould and Raga, 2002; Morton, 1987; White and Elson-Harris, 1994; Mitra and Bose, 2001	Yes	Fruit (CABI, 2011; Waterhouse, 1993)	Yes
Bactrocera tau (Walker)	Taiwan (CABI, 2011; Ohno et al., 2008)	Allwood et al., 1999	Yes	Fruit (Gould and Raga, 2002)	Yes
Hemiptera: Aleyrodidae					
Aleurocanthus spiniferus Quaintance & Baker	Taiwan (CABI, 2011); US (HI) (CABI, 2011)	PPQ, 2002	Yes	Leaves (CABI, 2011)	No
Aleurocanthus woglumi Ashby	Taiwan (EPPO/CABI, 1996); US (AZ, CA, FL, MS, TX, HI) (Evans, 2007b)	EcoPort Record, 2008; EPPO/CABI, 1996; Gould and Raga, 2002; Hill, 1983	[Yes][7]	Leaves (CABI, 2011; Gould and Raga, 2002; Hill, 1983; PPQ, 2002); fruit (Gould and Raga, 2002)	No[8]
Aleuroclava guyavae (Takahashi) (Syn: *Aleurotuberculatus guyavae* Takahashi)	Taiwan (Evans, 2007a; Mound and Halsey, 1978)	Evans, 2007a; Mound and Halsey, 1978; Pellizzari and Šimala, 2007	Yes	Leaves (Pellizzari and Šimala, 2007)	No[9]

[6] We found one report of *Euwallacea fornicatus* (Eichhoff) on fruit (Wang and Yuan, 2003), but all other reports list this species on bark, wood, branches, and stems. CABI (2011) also states that fruit are "not known to carry the pest in trade/transport." Hence, this beetle seems highly unlikely to follow the pathway of commercial guava fruit.

[7] Quarantine significant species with distribution in the United States (PestID, 2012).

[8] We found only one report of *A. woglumi* on fruit (Gould and Raga, 2002), but it is neither an original source, nor do the authors cite an original source. Additionally, there is one interception record of this pest on guava fruit (Pest ID, 2012). However, because this pest is primarily on leaves, it is very unlikely to follow the pathway of commercial fruit.

[9] There is very little information available on this pest in the literature. However, when this pest has been reported, there has been no visible damage. Additionally, whiteflies are primarily on leaves, and this pest is unlikely to follow the pathway of commercial fruit.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Aleuroclava psidii (Singh) (Syn: *Aleurotuberculatus psidii* (Sing))	Taiwan (Mound and Halsey, 1978)	Gould and Raga, 2002; Kwee and Chong, 1990; Mound and Halsey, 1978	Yes	Leaves (Wen et al., 2002; Yunus and Ho, 1980)	No
Aleurodicus dispersus Russell	Taiwan (BAPHIQ, 2011); US (HI, FL) (CABI, 2011)	BAPHIQ, 2011; CABI, 2011; EcoPort Record, 2008; Evans, 2007b; Gould and Raga, 2002	No[10]	N/A	N/A
Aleurolobus marlatti (Quaintance)	Taiwan (Mound and Halsey, 1978)	Evans, 2007b	Yes	Leaves (Hill, 1983)	No
Aleurolobus rhododendri (Takahashi)	Taiwan (Evans, 2007a)	Evans, 2007a	Yes	Leaves (Hill, 1983)[11]	No
Aleurolobus setigerus Quaintance & Baker	Taiwan (Hua, 2000; Mound and Halsey, 1978)	Evans, 2007b; Mound and Halsey, 1978	Yes	Leaves (Hill, 1983)[12]	No
Bemisia tabaci Gennadius	Taiwan (CABI, 2011); US (CABI, 2011)	EcoPort Record, 2008; Evans, 2007b	No	N/A	N/A
Dialeurodes citri (Ashmed)	Taiwan (CABI, 2011); US (CABI, 2011)	Evans, 2007b	No	N/A	N/A
Parabemisia myricae (Kuwana)	Taiwan (CABI, 2011; Evans, 2007b; Hua, 2000; Mound and Halsey, 1978); US (CABI, 2011)	CABI, 2011; Evans, 2007b; Gould and Raga, 2002; Hua, 2000; Mound and Halsey, 1978	[Yes][13]	Leaves, stems (CABI, 2011)	No
Hemiptera: Aphididae					
Aphis craccivora Koch	Taiwan (CABI, 2011); US (CABI, 2011)	Blackman and Eastop, 2000; Gould and Raga, 2002	No	N/A	N/A
Aphis gossypii Glover	Taiwan (BAPHIQ, 2011); US (CABI, 2011)	Blackman and Eastop, 2000; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; Hill, 1983; Mitchell, 1973	No	N/A	N/A

[10] Action only on propagative material (PestID, 2012).
[11] Plant parts attacked are based on biology at the genus level.
[12] Plant parts attacked are based on biology at the genus level.
[13] This pest is currently actionable at U.S. ports-of-entry, but its status is being re-evaluated based on its current distribution in the United States.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Aphis spiraecola Patch	Taiwan (CABI, 2011); US (CABI, 2011)	Blackman and Eastop, 2000; Gould and Raga, 2002	No	N/A	N/A
Greenidea ficicola Takahashi	Taiwan (Blackman and Eastop, 2000); US (FL) (Halbert, 2004)	Blackman and Eastop, 2000	No[14]	N/A	N/A
Greenidea psidii van der Goot (Syn: *G. formosana* Maki)	Taiwan (Blackman and Eastop, 2000); US (HI, FL) (Halbert, 2004)	Blackman and Eastop, 2000	No[15]	N/A	N/A
Myzus persicae (Sulzer)	Taiwan (CABI, 2011); US (CABI, 2011)	Blackman and Eastop, 2000; CABI, 2011; Gould and Raga, 2002	No	N/A	N/A
Toxoptera aurantii (Boyer de Fonscolombe)	Taiwan (CABI, 2011); US (CABI, 2011)	Blackman and Eastop, 2000; Gould and Raga, 2002	No	N/A	N/A
Hemiptera: Asterolecaniidae					
Russellaspis pustulans pustulans (Cockerell)	Taiwan (CABI, 2011)[16]; US (CABI, 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Hemiptera: Coccidae					
Ceroplastes floridensis Comstock (syn: *Paracerostegia floridensis* Tang)	Taiwan (Ben-Dov et al., 2011); US (CONUS) (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; CABI, 2011; Gould and Raga, 2002	No	N/A	N/A

[14] Action required only to Hawaii (PestID, 2012).
[15] Action required only in Hawaii (PestID, 2012).
[16] Unconfirmed record (CABI, 2011).

Pest Scientific Name	**Taiwan & U.S. Distribution**[1]	**Reported on Guava**	**Quarantine Pest**[2]	**Plant Part(s) Association**[3]	**Follow Pathway**[3]
Ceroplastes pseudoceriferus Green	Taiwan (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	Yes	Leaves, shoots, stems (Ali, 1980)	No
Ceroplastes rubens Maskell	Taiwan (Ben-Dov et al., 2011; CABI, 2011); US (HI, FL) (Ben-Dov et al., 2011; CABI, 2011; Hamon and Williams, 1984)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002	[Yes][17]	Fruit (CABI, 2011; Gould and Raga, 2002); leaves (CABI, 2011; Gould and Raga, 2002; Hamon and Williams, 1984); stems, branches, twigs (CABI, 2011; Gould and Raga, 2002; Hamon and Williams, 1984)	Yes
Coccus hesperidum L.	Taiwan (Ben-Dov et al., 2011; CABI, 2011); US (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Coccus longulus (Douglas)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008; HDOA, 2008	No	N/A	N/A
Coccus heperidum (L.)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Hill, 1983	No	N/A	N/A
Coccus viridis (Green)	Taiwan (BAPHIQ, 2011; Ben-Dov et al., 2011); US (HI, FL) (Ben-Dov et al., 2011; Mitchell, 1973)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; Mitchell, 1973	No[18]	N/A	N/A
Drepanococcus cajani (Maskell)	Taiwan (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	Yes	Leaves, fruit, flowers[19]	Yes
Drepanococcus chiton (Green)	Taiwan (Ben-Dov et al., 2011)	Mani and Krishnamoorthy, 1997	Yes	Leaves, flowers, fruit (Anupunt, 2003b)	Yes

17 Quarantine significant species with distribution in the United States (PestID, 2012).
18 Non-reportable/non-actionable as per the Deregulation Evaluation of Established Pests project (PestID, 2012).
19 We found no information on the plant part(s) attacked by *D. cajani*, but we assumed it can be found on fruit as *D. chiton* and other scale insects are.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Eucalymnatus tessellatus (Signoret)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Kilifia acuminata (Signoret)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008; Gould and Raga, 2002; HDOA, 2008	No	N/A	N/A
Milviscutulus mangiferae (Green)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Parasaissetia nigra (Nietner)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008; Gould and Raga, 2002; HDOA, 2008	No	N/A	N/A
Parthenolecanium persicae (Fabricius) (Syn: *Coccus elongatus* Fernald)	Taiwan (BAPHIQ, 2011; Ben-Dov et al., 2011); US (Ben-Dov et al., 2011; Commonwealth Institute of Entomology, 1979)	CABI, 2011; Hill, 1983	No	N/A	N/A
Prococcus acutissimus (Green) (Syn: *Coccus acutissimus* Fernald)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Protopulvinaria pyriformis (Cockerell)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Pulvinaria psidii Maskell (Syn: *Chloropulvinaria psidii* (Maskell)	Taiwan (BAPHIQ, 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; Hill, 1983; Morton, 1987; Mitra and Bose, 2001	No	N/A	N/A
Saissetia coffeae (Walker) (Syn: *S. hemisphaerica* (Targioni)	Taiwan (BAPHIQ, 2011; Ben-Dov et al., 2011); US (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; Gould and Raga, 2002; Hill, 1983	No	N/A	N/A

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Saissetia oleae (Olivier)	Taiwan (BAPHIQ, 2011); US (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Taiwansaissetia formicarii (Green)	Taiwan (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	Yes	Fruit[20]	Yes
Vinsonia stellifera (Westwood) (Syn: *Ceroplastes stellifera*)	Taiwan (Ben-Dov et al., 2011); US (HI, AL, GA, FL) (Ben-Dov et al., 2011)	EcoPort Record, 2008; Gould and Raga, 2002	[Yes][21]	Leaves, stems, fruit (Gould and Raga, 2002)	Yes
Hemiptera: Coreidae					
Leptocorisa acuta Thunberg	Taiwan (CABI, 2011)	CABI, 2011; EcoPort Record, 2008	Yes	Leaves, seeds (CABI, 2011)	No
Leptoglossus gonagra (Fabricius) (Syn: *L. australis* (Fabricius); *L. membranaceus* (Fabricius))	Taiwan (BAPHIQ, 2011); US (Mead, 1971)	CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Hemiptera: Diaspididae					
Abgrallaspis cyanophylli (Signoret) (syn: *Hemiberlesia cyanophylli* Ferris)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Aonidiella aurantii (Maskell)	Taiwan (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008; Gould and Raga, 2002	Yes[22]	Leaves, stems, fruit (CABI, 2011)	See appendix A
Aonidiella citrina (Coquillett)	Taiwan (Ben-Dov et al., 2011; CABI, 2011); US (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Aonidiella comperei (McKenzie)	Taiwan (Hua, 2000)	PestID, 2012[23]	Yes[24]	Leaves, stems, fruit (CABI, 2011)	See appendix A

[20] We found no information on the plant part(s) attacked by *T. formicarii*, but we assume it can be found on fruit like most Coccidae.
[21] Quarantine significant species with distribution in the United States (PestID, 2012).
[22] Armored scales are only actionable on propagative material, not on commodities for consumption. See appendix A.
[23] We found 9 interception records of this pest on guava fruit. All were in passenger baggage (PestID, 2012).
[24] Armored scales are only actionable on propagative material, not on commodities for consumption. See appendix A.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Aonidiella inornata McKenzie	Taiwan (Hua, 2000); US (HI, TX) (Ben-Dov et al., 2011)	PestID, 2012[25]	No	N/A	N/A
Aonidiella orientalis (Newstead)	Taiwan (Hua, 2000); US (CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; Gould and Raga, 2002; Kwee and Chong, 1990	No	N/A	N/A
Aspidiotus destructor Signoret	Taiwan (Ben-Dov et al., 2011; CABI, 2011); US (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; HDOA, 2008; Hill, 1983	No	N/A	N/A
Aulacaspis tubercularis Newstead	Taiwan (Hua, 2000); US (FL) (Hodges et al., 2005)	PestID, 2012[26]	No	N/A	N/A
Chrysomphalus aonidum (Linnaeus) (Syn: *C. ficus* Ashmead)	Taiwan (Ben-Dov et al., 2011; CABI, 2011); US (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Chrysomphalus dictyospermi (Morgan)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Hemiberlesia lataniae (Signoret)	Taiwan (BAPHIQ, 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; Hill, 1983	No	N/A	N/A
Hemiberlesia rapax (Comstock)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Howardia biclavis (Comstock)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A

[25] We found 6 interception records of this pest on guava fruit. All were in passenger baggage (PestID, 2012).
[26] We found 13 interception records of this pest on guava fruit. All were in passenger baggage (PestID, 2012).

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Ischnaspis longirostris (Signoret)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Lepidosaphes beckii (Newman)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	El-Minshawy et al., 1971	No	N/A	N/A
Lepidosaphes gloverii (Packard)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Lepidosaphes laterochitinosa Green	Taiwan (Ben-Dov et al., 2011); US (FL) (Thomas, 2000)	Ben-Dov et al., 2011	No	N/A	N/A
Morganella longispina (Morgan)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Parlatoria pergandii Comstock	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Parlatoria ziziphi (Lucas)	Taiwan (Ben-Dov et al., 2011); US (FL) (Ben-Dov et al., 2011)	PestID, 2012[27]	No	N/A	N/A
Pinnaspis aspidistrae (Signoret)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Pinnaspis strachani (Cooley)	Taiwan (Ben-Dov et al., 2011; CABI, 2011); US (CONUS) (Ben-Dov et al., 2011)	PestID, 2012[28]	No	N/A	N/A
Pseudaonidia duplex (Cockerell)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Gould and Raga, 2002	No	N/A	N/A

[27] This pest has been intercepted six times on guava fruit and once on leaves at U.S. ports of entry (PestID, 2012).

[28] We found three interception records of this pest on guava fruit, all in passenger baggage (PestID, 2012). However, because this pest is non-actionable for the United States, we did not search for substantiating evidence that guava is indeed a host of this pest.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Pseudaonidia trilobitiformis (Green)	Taiwan (Ben-Dov et al., 2011); US (FL) (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008	No	N/A	N/A
Octaspidiotus stauntoniae (Takahashi)	Taiwan (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	Yes[29]	Leaves, stems, fruit (CABI, 2011)	See appendix A
Selenaspidus articulates (Morgan)	Taiwan (Ben-Dov et al., 2011); US (Ben-Dov et al., 2011)	Gould and Raga, 2002	No	N/A	N/A
Unaspis citri (Comstock)	Taiwan (Ben-Dov et al., 2011); US (CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Hemiptera: Monophlebidae					
Icerya aegyptiaca (Douglas)	Taiwan (BAPHIQ, 2011; Ben-Dov et al., 2011; CABI, 2011)	BAPHIQ, 2011; Ben-Dov et al., 2011; CABI, 2011; Hill, 1983	Yes	Leaves, fruit (CABI, 2011; Hill, 1983); stems (CABI, 2011)	Yes
Icerya purchasi Maskell	Taiwan (BAPHIQ, 2011; CABI, 2011); US (BAPHIQ, 2011; CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Hill, 1983	No	N/A	N/A
Icerya seychellarum Westwood	Taiwan (BAPHIQ, 2011; CABI, 2011)	BAPHIQ, 2011; CABI, 2011; Gould and Raga, 2002; Hill, 1983; Yunus and Ho, 1980	Yes	Leaves, stems (CABI, 2011; Yunus and Ho, 1980); fruit[30]	Yes
Hemiptera: Pseudococcidae					
Dysmicoccus brevipes (Cockerell)	Taiwan (BAPHIQ, 2011); US (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008	No	N/A	N/A
Exallomochlus camur Willaims	Taiwan (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	Yes	Stems, fruit (PestID, 2012; ARS-SEL and APHIS, 2007)	Yes

[29] Armored scales are only actionable on propagative material, not on commodities for consumption. See appendix A.
[30] We found very little information on the plant part(s) attacked by *I. seychellarum*. We assumed it can be found on fruit, like *I. aegyptiaca* and most other scale insects.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Ferrisia virgata (Cockerell)	Taiwan (BAPHIQ, 2011; Ben-Dov et al., 2011); US (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; Hill, 1983	No	N/A	N/A
Geococcus coffeae Green	Taiwan (Hua, 2000); US (FL, HI) (Ben-Dov et al., 2011)	University of Hawaii, n.d.	[Yes][31]	Roots (Kuitert and Dekle, 1966)	No
Maconellicoccus hirsutus (Green) (syn: *Phenacoccus hirsutus* Green)	Taiwan (Ben-Dov et al., 2011; CABI, 2011); US (CA, FL) (CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; Gould and Raga, 2002; PPQ, 2002	[Yes][32]	Leaves (CABI, 2011; Gould and Raga, 2002); stems (CABI, 2011; Gould and Raga, 2002); fruit (CABI, 2011; Gould and Raga, 2002); bark (CABI, 2011)	Yes
Nipaecoccus filamentosus (Cockerell) (Syn: *Pseudococcus filamentosus* Fernald)	Taiwan (Hua, 2000)	Nair, 1974	Yes	Leaves, stems (Nair, 1974)	No
Nipaecoccus nipae (Maskell)	Taiwan (Hua, 2000); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; HDOA, 2008; Hill, 1983; Mitchell, 1973	No	N/A	N/A
Nipaecoccus viridis (Newstead) (Syn: *N. vastator* (Maskell))	Taiwan (BAPHIQ, 2011; Ben-Dov et al., 2011; CABI, 2011); US (HI) (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011; CABI, 2011; Gould and Raga, 2002	Yes	Fruit (Ben-Dov et al., 2011; CABI, 2011; Gould and Raga, 2002); leaves (Ben-Dov et al., 2011; CABI, 2011; Gould and Raga, 2002); twigs, branches (Ben-Dov et al., 2011)	Yes
Planococcus citri (Risso)	Taiwan (Ben-Dov et al., 2011; CABI, 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011; CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; Mitra and Bose, 2001	No	N/A	N/A

[31] Quarantine significant species with limited distribution in the United States (PestID, 2012).
[32] Quarantine significant species with limited distribution in the United States (PestID, 2012).

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Planococcus lilacinus (Cockerell) (Syn: *Psuedococcus lilacinus* Cockerell)	Taiwan (BAPHIQ, 2011; Ben-Dov et al., 2011)	Ben-Dov et al., 2011; CABI, 2011; Gould and Raga, 2002	Yes	Fruit (CABI, 2011; Gould and Raga, 2002; Wen et al., 2002); leaves (Wen et al., 2002; Yunus and Ho, 1980)	Yes
Planococcus minor (Maskell)	Taiwan (BAPHIQ, 2011; Ben-Dov et al., 2011)	Ben-Dov et al., 2011; CABI, 2011; Gould and Raga, 2002	No[33]	N/A	N/A
Psuedococcus comstocki (Kuwana)	Taiwan (Hua, 2000); US (Ben-Dov et al., 2011)	PestID, 2012	No	N/A	N/A
Pseudococcus cryptus Hempel (syn: *P. citriculus* Green)	Taiwan (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	Yes	Roots (Ben-Dov et al., 2011; Williams and Watson, 1988); fruit (Williams and Watson, 1988)	Yes
Pseudococcus jackbeardsleyi Gimpel & Miller	Taiwan (Ben-Dov et al., 2011; CABI, 2011); US (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	No	N/A	N/A
Pseudococcus longispinus (Targioni Tozzetti)	Taiwan (BAPHIQ, 2011); US (Ben-Dov et al., 2011; CABI, 2011)	Ben-Dov et al., 2011; EcoPort Record, 2008; Gould and Raga, 2002	No	N/A	N/A
Rastrococcus spinosus (Robinson) (Syn: *Pehnacoccus spinosus* Robinson, *Puto spinosus* Morrison)	Taiwan (Ben-Dov et al., 2011)	Ben-Dov et al., 2011	Yes	Fruit, flowers (Ottanes, 1936)	Yes
Lepidoptera: Actiidae					
Amsacta lactinea (Cramer)	Taiwan (White and Elson-Harris, 1994)	Robinson et al., 2007	Yes	Leaves (Waterhouse, 1993)	No

[33] Non-reportable/non-actionable as per the Deregulation Evaluation of Established Pests project (PestID, 2012).

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Lepidoptera: Cossidae					
Zeuzera coffeae Neitner	Taiwan (CABI, 2011; Robinson et al., 2007)	Anupunt, 2003a; Kuroko and Lewvanich, 1993; Robinson et al., 2007	Yes	Branches, stems (Anupunt, 2003a)	No
Lepidoptera: Geometridae					
Hyposidra infixaria Walker	Taiwan (Hua, 2005)	Robinson et al., 2007	Yes	Leaves (Robinson et al., 2001)	No
Hyposidra talaca (Walker)	Taiwan (Hua, 2005)	Anupunt, 2003a; Kuroko and Lewvanich, 1993; Robinson et al., 2007	Yes	Leaves (Anupunt, 2003a; Waterhouse, 1993)	No
Pingasa ruginaria Guenee	Taiwan (Hua, 2005)	Robinson et al., 2007	Yes	Leaves (Wongsiri, 1991)	No
Lepidoptera: Lasiocampidae					
Trabala vishnou Lefebvre	Taiwan (Hua, 2005)	Robinson et al., 2007	Yes	Leaves, twigs (Sah et al., 2007)	No
Lepidoptera: Limacodidae					
Chalcocelis albiguttatus (Snellen)	Taiwan (Hua, 2005)	Zhang, 1994	Yes	Leaves (Pena et al., 2002)	No
Thosea sinensis (Walker)	Taiwan (Hua, 2005; White and Elson-Harris, 1994)	Hill, 1983	Yes	Leaves (Robinson et al., 2001)	No
Lepidoptera: Lycaenidae					
Euchrysops cnejus Fabricius	Taiwan (Hua, 2005)	EcoPort Record, 2008	Yes	Flowers, leaves (Robinson et al., 2001)	No
Rapala varuna Horsfield	Taiwan (Robinson et al., 2007)	Robinson et al., 2007; Zhang, 1994	Yes	Flowers (Lambkin, 1983; Storey and Rogers, 1980); green stems (Lambkin, 1983); leaves (Yunus and Ho, 1980)	No
Lepidoptera: Lymantriidae					
Chalcocelis albiguttatus (Snellen)	Taiwan (Hua, 2005)	Robinson et al., 2007; Zhang, 1994	Yes	Leaves (Ooi et al., 2002)	No
Euproctis scintillans (Walker) (Syn: *Porthesia scintillans* Walker)	Taiwan (Hua, 2005)	Waterhouse, 1993; Yunus and Ho, 1980	Yes	Leaves (Hill, 1983; Waterhouse, 1993; Yunus and Ho, 1980)	No
Lymantria monacha L.	Taiwan (Hua, 2005)	Gould and Raga, 2002; Zhang, 1994	Yes	Leaves (Gould and Raga, 2002)	No

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Lymantria xylina (Swinhoe)	Taiwan (BAPHIQ, 2011; Gould and Raga, 2002; Zhang, 1994)	Gould and Raga, 2002	Yes	Leaves (BAPHIQ, 2011; Gould and Raga, 2002)	No
Notolophorus australis Walker (Syn: *Orgyia australis Walker*)	Taiwan (BAPHIQ, 2011)	BAPHIQ, 2011	Yes	Leaves, flowers, shoots, fruit (BAPHIQ, 2011)	No[34]
Porthesia taiwana Shiraki (Syn: *Euproctis taiwana* Shiraki)	Taiwan (BAPHIQ, 2011; Zhang, 1994)	BAPHIQ, 2011	Yes	Leaves, flowers, shoots, fruit (BAPHIQ, 2011)	No[35]
Lepidoptera: Noctuidae					
Achaea janata (Linnaeus)	Taiwan (Hua, 2005)	EcoPort Record, 2008; Robinson et al., 2001; Robinson et al., 2007; Zhang, 1994	Yes	Fruit (CABI, 2011); leaves (CABI, 2011; Storey and Rogers, 1980; Waite and Hwang, 2002)	No[36]
Asota caricae (Fabricius)	Taiwan (Hua, 2005)	Kuroko and Lewvanich, 1993; Robinson et al., 2007	Yes	Leaves (Kuroko and Lewvanich, 1993; Robinson et al., 2007)	No
Eudocima fullonia (Clerck) (Syn: *Othreis fullonia* Clerck, *O. fullonica* Linn.)	Taiwan (BAPHIQ, 2011); US (HI) (CABI, 2011; Zhang, 1994)	CABI, 2011; EcoPort Record, 2008; Gould and Raga, 2002; Hill, 1983	Yes	Fruit (CABI, 2011; Gould and Raga, 2002; Waterhouse, 1993)	No[37]

[34] *Notolophorus australis*, like other tussock moths is an external feeder. Larvae generally feed on leaves and are not typically associated with fruit. Any larvae feeding on fruit are highly unlikely to remain on the commodity through harvest and processing.

[35] *Porthesia taiwana*, like other tussock moths is an external feeder. Larvae generally feed on leaves and are not typically associated with fruit. Any larvae feeding on fruit are highly unlikely to remain on the commodity through harvest and processing.

[36] *Achaea janata* is highly unlikely to follow the pathway because the only life stage that feeds on fruit is the highly mobile adult (CABI, 2011).

[37] This pest is a fruit-piercing moth (Anupunt, 2003b; CABI, 2011; Gould and Raga, 2002; Wongsiri, 1991), so only the adults feed on fruit, and only externally (CABI, 2007). Furthermore, they only feed at night (CABI, 2007), decreasing the chance of being on the fruit when harvested. Because the adults are relatively large and mobile, this pest is highly unlikely to stay on the commodity through harvest and standard handling and processing.

Pest Scientific Name	**Taiwan & U.S. Distribution**[1]	**Reported on Guava**	**Quarantine Pest**[2]	**Plant Part(s) Association**[3]	**Follow Pathway**[3]
Helicoverpa armigera Hubner) (Syn: *Heliothis armigera*)	Taiwan (CABI, 2011; Hua, 2005)	Gould and Raga, 2002; Kwee and Chong, 1990	Yes	Fruit (internal) (Gould and Raga, 2002; Kwee and Chong, 1990); flowers (Gould and Raga, 2002); leaves (Gould and Raga, 2002)	Yes
Oraesia emarginata (Fabricius)	Taiwan (Hua, 2005)	Zhang, 1994	Yes	Leaves, fruit	No[38]
Spodoptera litura (Fabricius) (Syn: *Prodenia litura* Fabricius)	Taiwan (CABI, 2011); US (HI) (CABI, 2011)	Robinson et al., 2001; Robinson et al., 2007	Yes	Leaves (CABI, 2011); roots, fruit (CABI, 2011)	No[39]
Xanthodes transversa (Guenee)	Taiwan (Hua, 2005)	Kuroko and Lewvanich, 1993; Robinson et al., 2007	Yes	Leaves (Kuroko and Lewvanich, 1993)	No
Lepidoptera: Olethreutidae					
Strepsicrates rhothia (Meyrick)	Taiwan (White and Elson-Harris, 1994)	Gould and Raga, 2002; Kwee and Chong, 1990; Robinson et al., 2007; Zhang, 1994	Yes	Leaves (Kwee and Chong, 1990)	No
Lepidoptera: Psychidae					
Eumeta minuscula Butler	Taiwan (Hua, 2005; Zhang, 1994)	Gould and Raga, 2002; Kwee and Chong, 1990; Robinson et al., 2007	Yes	Leaves (Kwee and Chong, 1990)	No
Eumeta variegata (Snellen) (Syn: *Clania variegata* Snellen, *C. pryeri* Leech)	Taiwan (Zhang, 1994)	Robinson et al., 2007	Yes	Leaves (Sun et al., 1999)	No
Oiketicoides javana Heylaerts (Syn: *Clania destructor* Dudgeon)	Taiwan (White and Elson-Harris, 1994)	Robinson et al., 2007	Yes	Leaves (Robinson et al., 2001)	No
Lepidoptera: Pyralidae					
Cadra cautella (Walker) (syn: *Ephestia cautella* Walker)	Taiwan (BAPHIQ, 2011); US (CABI, 2011)	BAPHIQ, 2011; CABI, 2011	No	N/A	N/A

[38] Only the adults feed on the fruit, and they only feed on the fruit externally (CABI, 2011).
[39] Some reports state that *S. litura* feeds on fruit. However, it is mainly a leaf-feeder (e.g., CABI, 2011; Hill, 1983; Robinson et al., 2001), and we found no evidence that it feeds on guava fruit.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Conogethes punctiferalis (Guenée) (Syn: *Dichocrocis punctiferalis* Guenée)	Taiwan (BAPHIQ, 2011)	BAPHIQ, 2011; Gould and Raga, 2002; Robinson et al., 2007; Zhang, 1994	Yes	Fruit (CABI, 2011; Gupta and Arora, 2001; Waterhouse, 1993; Yunus and Ho, 1980); flowers (Waterhouse, 1993); stems, leaves, bark (CABI, 2011)	Yes
Lepidoptera: Saturniidae					
Attacus atlas (Linnaeus)	Taiwan (BAPHIQ, 2011; CABI, 2011)	BAPHIQ, 2011; CABI, 2011	Yes	Leaves (CABI, 2011; Waterhouse, 1993; Yunus and Ho, 1980)	No
Samia cynthia (Drury)	Taiwan (Hua, 2005); US (CABI, 2011)	Zhang, 1994	No	N/A	N/A
Lepidoptera: Tineidae					
Setomorpha rutella Zeller	Taiwan (Hua, 2005); US (Opler et al., 2010)	Robinson et al., 2007; Zhang, 1994	No	N/A	N/A
Lepidoptera: Tortricidae					
Adoxophyes privatana Walker	Taiwan (Zhang, 1994)	Robinson et al., 2007	Yes	Leaves (Waterhouse, 1993; Yunus and Ho, 1980)	No
Dudua aprobola (Meyrick)	Taiwan (Hua, 2005)	Gould and Raga, 2002; Zhang, 1994	Yes	Leaves (Gould and Raga, 2002)	No
Homona coffearia (Nietner)	Taiwan (BAPHIQ, 2011; CABI, 2011)	BAPHIQ, 2011; CABI, 2011; Robinson et al., 2007	Yes	Leaves (CABI, 2011; Hill, 1983; Waterhouse, 1993)	No
Strepsicrates rhothia Meyrick	Taiwan (Zhang, 1994)	Kwee and Chong, 1990; Zhang, 1994	Yes	Young leaves, foliar buds (Kwee and Chong, 1990)	No
Thysanoptera: Phlaeothripidae					
Haplothrips gowdeyi (Franklin)	Taiwan (Hua, 2000); US (CABI, 2011)	Camacho-Molina et al., 2002	No	N/A	N/A
Thysanoptera: Thripidae					
Heliothrips haemorrhoidalis Bouché	Taiwan (BAPHIQ, 2011); US (CABI, 2011)	CABI, 2011; EcoPort Record, 2008	No	N/A	N/A

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Rhipiphorothrips cruentatus Hood	Taiwan (BAPHIQ, 2011; Hua, 2000)	BAPHIQ, 2011; CABI, 2011	Yes	Fruit (BAPHIQ, 2011; CABI, 2011; Gima et al., 2001); leaves (CABI, 2011; Wen et al., 2002)	Yes
Scirtothrips dorsalis Hood	Taiwan (CABI, 2011; Hua, 2000); US (HI, FL) (CABI, 2011)	Gould and Raga, 2002	[Yes] [40]	Flowers (Anupunt, 2003a; CABI, 2011); shoots (CABI, 2011; Waite and Hwang, 2002); leaves (Anupunt, 2003a; CABI, 2011); young fruit (Anupunt, 2003a; CABI, 2011)	No[41]
Selenothrips rubrocinctus (Giard)	Taiwan (BAPHIQ, 2011; Hua, 2000); US (CABI, 2011)	BAPHIQ, 2011; Gould and Raga, 2002	No	N/A	N/A
Thrips hawaiiensis (Morgan)	Taiwan (CABI, 2011; Hua, 2000); US (CABI, 2011; HDOA, 2008)	HDOA, 2008	No	N/A	N/A
PATHOGENS					
Fungi and Chromistans					
Botryodiplodia sp.	Taiwan (Zengzhoung, 2005)	Zengzhoung, 2005	Yes	Fruit, leaves, stems (Zengzhoung, 2005)	Yes
Botrytis cinerea Pers	Taiwan (Zengzhoung, 2005); US (Farr et al., 2010)	Zengzhoung, 2005	No	N/A	N/A
Cephaleuros virescens Kunze	Taiwan (Zengzhoung, 2005); US (Farr et al., 2010)	Zengzhoung, 2005	No	N/A	N/A
Colletotrichum gloeosporioides (Penz.) Sacc. (Syn:	Taiwan (Zengzhoung, 2005); US (Farr et al., 2010)	Zengzhoung, 2005	No	N/A	N/A

[40] Quarantine-significant species with limited distribution in the United States (PestID, 2012).
[41] Guava fruit for fresh marketing and shipping are harvested when mature. *Scirtothrips dorsalis* only attacks immature fruit (CABI, 2011) so it is highly unlikely to be on harvested fruit and to follow the pathway of commercial guava fruit.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Drechslera sp.	Taiwan (Zengzhoung, 2005)	Zengzhoung, 2005	Yes	Leaves (Zengzhoung, 2005)	No
Glomerella cingulata (Stonem.) Spauld. & Schrenk [teleomorph]	Taiwan (Zengzhoung, 2005); US (Farr et al., 2010)	Zengzhoung, 2005	No	N/A	N/A
Myxosporium psidii Sawada et Kurosawa [Anamorph: *Nalanthamala psidii* Incertae sedis]	Taiwan (Farr et al., 2010; Schroers et al., 2005)	Zengzhoung, 2005	Yes	Leaves, stems (Zengzhoung, 2005); trunk, branches	No
Pestalotiopsis psidii (Pat.) Mordue	Taiwan (Zengzhoung, 2005)	Zengzhoung, 2005	Yes	Fruit, leaves, stems (Zengzhoung, 2005)	Yes
Pestalotiopsis sp.	Taiwan (Zengzhoung, 2005)	Zengzhoung, 2005	Yes	Leaves, fruit (Zengzhoung, 2005)	No
Phomopsis sp.	Taiwan (Zengzhoung, 2005)	Zengzhoung, 2005	Yes	Fruit, stems (Zengzhoung, 2005)	Yes
Phytophthora nicotianae Breda de Haan (Syn: *P. parasitica* Dastur)	Taiwan (Zengzhoung, 2005); US (Farr et al., 2009)	Zengzhoung, 2005	No	N/A	N/A
Rhizoctonia sp.	Taiwan (Zengzhoung, 2005)	Zengzhoung, 2005	Yes	Fruit, leaves, stems (Zengzhoung, 2005)	Yes
Thanatephorus cucumeris (A.B. Frank) Donk, [Anamorph: ***Rhizoctonia solani*** Kühn]	Taiwan; US (Farr and Rossman, 2012)	Farr and Rossman, 2012	No	N/A	N/A
Sphaceloma pisdii Bitanc. & Jenk.	Taiwan (PestID, 2010); US (FL) (Farr et al., 2010)	Farr et al., 2010	No[42]	N/A	N/A
Nematoda					
Meloidogyne incognita (Kofoid and White) Chitwood	Taiwan (Zengzhoung, 2005); US (CABI, 2011)	Zengzhoung, 2005	No	N/A	N/A

[42] *Sphaceloma pisdii* is a quarantine pest only when entering Hawaii (PestID, 2010). Since this analysis only covers the continental states, *Sphaceloma pisdii* is not a pest in this context.

Pest Scientific Name	Taiwan & U.S. Distribution[1]	Reported on Guava	Quarantine Pest[2]	Plant Part(s) Association[3]	Follow Pathway[3]
Pratylenchus sp.	Taiwan (Zengzhoung, 2005)	Zengzhoung, 2005	Yes	Roots (Zengzhoung, 2005)	No

Below we summarized the quarantine pests that are reasonably likely to follow the pathway on commercial shipments of guava from Taiwan and that further analyzed in this risk assessment (Table 4). Quarantine pests not included in this summary have the potential to be detrimental to U.S. agriculture or ecosystems; however, they have not been subjected to further analysis because they are mainly associated with plant parts other than the commodity; they may be more reasonably associated with larger diameter stems or branches than with the 3-4 mm diameter stems associated with guava fruit; they may have a greater association with new stem or leaf growth rather than with mature fruit-bearing peduncles at harvest time; or they are unlikely to be associated with the fruit during transport or processing because of their inherent mobility.

Biological hazards associated with organisms not identified to the species level were not assessed because often there are many species within a genus, and it is not reasonable to assume that the biology of all organisms within a genus is identical. Lack of specific identification may indicate the limits of current taxonomic knowledge, the life stage or the quality of the specimen submitted for identification. By necessity, pest risk assessments focus on organisms for which biological information is available. Lack of specific identification does not rule out the possibility that a high risk quarantine pest was intercepted. Conversely, the development of detailed assessments for known pests that inhabit a variety of ecological niches, such as internal fruit feeders or foliage pests, allow effective mitigation measures to eliminate the known organisms as well as similar but incompletely identified organisms that inhabit the same niche. If pests identified to higher taxa are intercepted in the future, then a re-evaluation of their risk may occur.

Table 4. Quarantine pests likely to be associated with guava imported from Taiwan and selected for further analysis.

Taxonomy	Organism
Arthropods	
Acari: Tetranychidae	*Eutetranychus orientalis* (Klein)
	Oligonychus biharensis (Hirst)
	Oligonychus litchi Lo & Ho
Diptera: Tephritidae	*Bactrocera cucurbitae* (Coquillett)
	Bactrocera dorsalis (Hendel)
	Bactrocera tau (Walker)
Hemiptera: Coccidae	*Ceroplastes rubens* Maskell
	Drepanococcus cajani (Maskell)
	Drepanococcus chiton (Green)

Taxonomy	**Organism**
	Taiwansaissetia formicarii (Green)
	Vinsonia stellifera (Westwood)
Hemiptera: Monophlebidae	*Icerya aegyptiaca* (Douglas)
	Icerya seychellarum Westwood
Hemiptera: Pseudococcidae	*Exallomochlus camur* Williams
	Maconellicoccus hirsutus (Green)
	Nipaecoccus viridis (Newstead)
	Planococcus lilacinus (Cockerell)
	Pseudococcus cryptus Hempel
	Rastrococcus spinosus (Robinson)
Lepidoptera: Noctuidae	*Helicoverpa armigera* (Hubner)
Lepidoptera: Pyralidae	*Conogethes punctiferalis* (Guenée)
Thysanoptera: Thripidae	*Rhipiphorothrips cruentatus* Hood
Pathogen	
Ascomycetes: Xylariales	*Pestalotiopsis psidii* (Pat.) Mordue

2.5 Analysis of Quarantine Pests

The undesirable consequences that may occur from the introduction of quarantine pests are assessed within this section. For each quarantine pest, the potential consequences of introduction are rated in five areas called “Risk Elements.” The Risk Elements include: Climate-Host Interaction, Host Range, Dispersal Potential, Economic Impact, and Environmental Impact. These Risk Elements reflect the biology, host range, and climatic/geographic distribution of each pest and are supported by biological information on each of the analyzed pests summarized in this section. For each risk element, pests are assigned a rating of Low (1 point), Medium (2 points) or High (3 points). A cumulative risk value is then calculated by summing the ratings. The following scale is used to interpret this total: Low is 5-8 points, Medium is 9-12 points and High is 13-15 points. The ratings are summarized in Table 5. The ratings were determined using the criteria in the *Guidelines for Pathway-Initiated Pest Risk Assessments Version 5.02* (USDA, 2000).

The major sources of uncertainty present in this risk include the use of a developing or evolving process (Orr et al., 1993; USDA, 2000), the approach used to combine risk elements (Bier, 1999; Morgan and Henrion, 1990), and the evaluation of risk by comparisons to lists of factors within the guidelines (Kaplan, 1992; Orr et al., 1993). To address this last source of uncertainty, the lists of factors were interpreted as illustrative and not exhaustive. This implies that additional biological information, even if not explicitly part of the criteria, can be used when it is relevant to a rating. Other sources of uncertainty are the quality of the biological information and the amount of information available on the regional flora and fauna. Inherent biological variation within a population of organisms introduces uncertainty as well (Morgan and Henrion, 1990).

2.5.1. Consequences of Introduction—Economic/Environmental Importance

Potential consequences of introduction are rated using five risk elements: Climate-Host Interaction, Host Range, Dispersal Potential, Economic Impact, and Environmental Impact. These elements reflect the biology, host ranges and climatic/geographic distributions of the pests. For each risk element, pests are assigned a rating of Low (1 point), Medium (2 points), or High (3 points) (USDA, 2000).

Acari: Tetranychidae*: Eutetranychus orientalis, Oligonychus biharensis, O. litchi*

Risk Element #1: Climate-Host Interaction

The spider mites *Eutetranychus orientalis, Oligonychus biharensis,* and *O. litchi* have tropical/subtropical distributions.

- *Eutetranychus orientalis* has been reported in Afghanistan, Australia, Cape Verde, China, Cyprus, Egypt, Ethiopia, Hong Kong, India, Iran, Iraq, Israel, Japan, Jordan, Kenya, Kuwait, Lebanon, Malawi, Mali, Mauritania, Mozambique, Nigeria, Pakistan, Philippines, Saudi Arabia, Senegal, South Africa, Sudan, Taiwan, Thailand, Tunisia, Turkey, the United Arab Emirates, Vietnam, and Yemen (Bolland et al., 1998)
- *Oligonychus biharensis* has been reported in American Samoa, Antigua, Australia, Bangladesh, Brazil, China, Fiji, Hawaii, India, Malaysia, Mexico, New Caledonia, Okinawa Island, Papua New Guinea, the Philippines, South Africa, Taiwan, Thailand, Tonga, Wallis and Futuna, and Western Samoa (Bolland et. al, 1998)
- *Oligonychus litchi* has only been reported from Taiwan (Bolland et. al, 1998)

Based on a comparison of the current distribution of each of these species with a global map of USDA Plant Hardiness Zones (Magarey et al., 2008), we estimated that all of these spider mites could establish in U.S. Plant Hardiness Zones 9-11. One or more of their potential hosts occur in these zones (NRCS, 2011). We rated *Eutetranychus orientalis, Oligonychus biharensis,* and *O. litchi* **Medium** for this risk element.

Risk Element #2: Host Range

Eutetranychus orientalis, Oligonychus biharensis, and *O. litchi* are all polyphagous pests, attacking hosts in multiple families and genera.

- *Eutetranychus orientalis* is primarily a pest of citrus (Jeppson et al., 1975), but has been reported on over 200 hosts in families such as Euphorbiaceae (*Euphorbia* spp.), Fabaceae (*Bauhinia* spp., *Cassia* spp., *Erythrina* spp., etc.), Lauraceae (*Persea americana*), Mimosoideae (*Acacia* spp.), Moraceae (*Artocarpus* spp., *Ficus* spp.), Myrtaceae (*Psidium guajava,*), Punicaceae (*Punica granatum*), Rosaceae (*Prunus* spp., *Rosa* spp., *Pyrus* spp.), Rutaceae (*Citrus* sp.), and Vitaceae (*Vitis vinifera*) (Bolland et al., 1998)
- *Oligonychus bihrensis* has been reported on hosts in families such as Anacardiaceae (*Mangifera indica*), Araceae (*Colocasia esculenta*), Ebenaceae (*Diospyros* spp.), Euphorbiaceae (*Euphorbia longana*), Fabaceae (*Bauhinia* spp., *Cassia* spp., *Erythrina* spp.), Lauraceae (*Cinnamomum camphora; Persea americana*), Mimosoideae (*Acacia* spp.), Moraceae (*Artocarpus* spp., *Ficus* spp.), Myrtaceae (*Psidium guajava*), Phyllanthaceae (*Bischofia javanica*), Rosaceae (*Eriobotrya* spp., *Rosa* spp., *Pyrus* spp.), Rutaceae (*Citrus* sp.), Sapindaceae (*Litchi chinensis*), and Vitaceae (*Ampelopsis heterophylla*) (Bolland et al., 1998)
- *Oligonychus litchi* has been reported on hosts in the families Anacardiaceae (*Mangifera indica*), Euphorbiaceae (*Euphorbia longana*), Fabaceae (*Bauhinia* spp., *Erythrina*

Acari: Tetranychidae*: Eutetranychus orientalis, Oligonychus biharensis, O. litchi*

corallodendrum), Meliaceae (*Azadirachta indica*), Moraceae (*Ficus* spp.), Myrtaceae (*Psidium guajava*, *Syzygium samarangense*), Rosaceae (*Eriobotrya japonica*), and Sapindaceae (*Litchi chinensis*) (Bolland et al., 1998)

We rated the three pests **High** for this risk element.

Risk Element #3: Dispersal Potential

Spider mites have a relatively high biotic potential. For example, fecundity of female spider mites generally ranges between 30 and 50 eggs per female (Jeppson et al., 1975). They have multiple generations per year: under optimal conditions, *E. orientalis* can have up to 25 generations per year and some species of *Oligonychus* have as many as 30 (CABI, 2011; Jeppson et al., 1975). Spider mites have a limited capacity to disperse on their own. "Ballooning" on wind currents is their main means of natural dispersal; long-distance dispersal is accomplished via infested plant material (CABI, 2011; Jeppson et al., 1975). Because spider mites have a high biotic potential but a relatively low ability to spread, we rated all three species **Medium**.

Risk Element #4: Economic Impact

Eutetranychus orientalis and *Oligonychus biharensis* are both important agricultural pests, included on the ranked list of potentially invasive pest species of Tetraychoidea by the Acarological Society of America (Childers et al., 2006). *Eutetranychus orientalis* is a serious pest of citrus that generally feeds on the upper leaf surface, producing a multitude of gray spots, and giving leaves a chlorotic appearance (Gould and Raga, 2002; Jeppson et al., 1975; Mitchell, 1973). *Oligonychus biharensis* is a pest of several agricultural crops, including avocado, mango, grapes, roses, pome fruit, and guavas (Jeppson et al., 1975). It typically feeds on the underside of leaves, causing them to become dull green, and then bronzed (Gould and Raga, 2002). In both cases, infested leaves weaken and finally drop, resulting in bare trees in nurseries or neglected orchards. Blossoming can also be affected, which results in the following season's yield being very small (Avidov and Harpaz, 1969). When these mites occasionally feed on fruit, the resulting damage has a corky and tan appearance, which may reduce marketability (Gould and Raga, 2002; Jeppson et al., 1975; Mitchell, 1973). *Eutetranychus orientalis* and *O. biharensis* are both quarantine pests for multiple countries and regional plant protection organizations, suggesting that their introduction could lead to restrictions on host commodities (e.g., citrus, grapes) to markets outside of this pest's distribution (APHIS, 2012b). We rated both of these pests **High** for this risk element.

Much less is known about *O. litchi.* We assume the damage caused by this pest is similar to the damage caused by other spider mites, including *O. biharensis.* Commercial hosts include mango, guava, and litchi, none of which are exported. Therefore, we rated this pest **Medium**.

Risk Element #5: Environmental Impact

Examples of potential hosts listed by the Federal government as Threatened or Endangered that occur in areas of the continental United States suitable for the survival of *E. orientalis* include *Prunus geniculata* (in Florida), *Manihot walkerae* (in Texas), and *Ziziphus celata* (in Florida); these plants are closely related to other plants known to be attacked by *E. orientalis. Manihot walkerae* is also a potential host of *O. biharensis.* These pests attack important crops such as citrus, avocado, grapes, and pome fruit, but should they become established in the United States, measures (e.g., application of miticides) already employed to control other spider mites on these crops would likely be equally effective against them. Therefore, we rated *E. orientalis* and *O. biharensis* both **Medium** for this risk element.

Acari: Tetranychidae*: Eutetranychus orientalis, Oligonychus biharensis, O. litchi*

Based on its known host range, *O. litchi* is unlikely to pose a threat to Threatened and Endangered plants in the United States and would likely be controlled by measures already employed to control spider mites. We rated it **Low** for this risk element.

Diptera: Tephritidae *Bactrocera cucurbitae, B. dorsalis,* and *B. tau*

Risk Element #1: Climate-Host Interaction

Bactrocera spp. generally have tropical/ subtropical distributions.

- *Bactrocera caudata* has been reported from Brunei, Myanmar (Burma), Taiwan, Sri Lanka, Malaysia, Thailand, Vietnam, Nepal, Indonesia, India, and Singapore (Kapoor, 1993; White and Elson-Harris, 1994)
- *Bactrocera dorsalis* is currently distributed in Bangladesh, Bhutan, Cambodia, southern China, French Polynesia, Guam, Hawaii, India, Laos, Mariana Islands, Myanmar, Nauru, Nepal, Pakistan, Palau, Sri Lanka, Taiwan, northern Thailand, and Vietnam (Aketarawong et al., 2007; Drew and Hancock, 1994; Khalid and Mishkatullah, 2007; Vargas et al., 2007; White and Elson-Harris, 1994)
- *Bactrocera tau* is widely distributed throughout East Asia, including Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Sri Lanka, Taiwan, Thailand, and Vietnam (CABI, 2011; Kapoor, 1993; White and Elson-Harris, 1994)

Based on a comparison of the current distribution of these species with a global map of USDA Plant Hardiness Zones (Magarey et al., 2008), we estimated that all of these species of fruit flies could survive in U.S. Plant Hardiness Zones 9-11. One or more of the potential hosts of each of these fruit flies occurs in these zones. Therefore, we rated those fruit flies **Medium**.

Bactrocera cucurbitae is distributed in Asia from Saudi Arabia in the west to Taiwan in the east, south through Indonesia, and in China from Jiangsu in the north to Hainan in the south (CABI, 2011). It also occurs in northeastern Australia, in multiple countries in Africa, and in various island groups of the Pacific, including Hawaii (CABI, 2007; EPPO, 2006). Based on a comparison of the current distribution of these species with a global map of USDA Plant Hardiness Zones (Magarey et al., 2008), we estimated that this fruit fly could survive in U.S. Plant Hardiness Zones 7-11. One or more of the potential hosts this fruit fly occurs in these zones. Therefore, we rated *B.cucurbitae* **High** for this risk element.

Risk Element #2: Host Range

Bactrocera cucurbitae, B. dorsalis, and *B. tau* are all polyphagous pests, attacking hosts in multiple families and genera.

- *Bactrocera cucurbitae* is primarily a host of cucurbits (Cucurbitaceae) such as *Cucumis melo, Cucurbita maxima, Cucurbita pepo,* and *Trichosanthes cucumerina*. Secondary hosts from the Cucurbitaceae include *Benincasa hispida, Citrullus colocynthis,* and *Cucumis anguria*. Additional secondary hosts occur in the families Rosaceae (e.g., *Prunus persica*), Rutaceae (e.g., Citrus *sinensis*), Fabaceae (e.g., *Phaseolus vulgaris*), Loganiaceae (*Strychnos nux-vomica*), Malvaceae (*Abelmoschus moschatus*), Myrtaceae (*Psidium guajava*), Pandanaceae (*Pandanus odoratissimus*), Passifloraceae (*Passiflora*

Diptera: Tephritidae *Bactrocera cucurbitae, B. dorsalis,* and *B. tau*

edulis), Rhamnaceae (e.g., *Ziziphus jujube*), Sapotaceae (*Manilkara zapota*), Solanaceae (*Lycopersicon esculentum*), and Sapindaceae (Psidium guajava) (White and Elson-Harris, 1994)

- *Bactrocera dorsalis* attacks over three hundred wild and cultivated plants (Mau et al., 2007), including plants in the following families and genera: Anacardiaceae (*Anacardium, Mangifera, Spondias*), Annonaceae (*Annona*), Arecaceae (*Areca*), Caricaceae (*Carica*), Combretaceae (*Terminalia*), Cucurbitaceae (*Cucumis, Momordica*), Ebenaceae (*Diospyros*), Flacourtiaceae (*Flacourtia*), Lauraceae (*Persea*), Malpighiaceae (*Malpighia*), Moraceae (*Artocarpus, Ficus*), Musaceae (*Musa*), Myrtaceae (*Syzygium, Psidium*), Oxalidaceae (*Averrhoa*), Punicaceae (*Punica*), Rhamnaceae (*Ziziphus*), Rosaceae (*Malus, Prunus, Pyrus*), Rubiaceae (*Coffea*), Rutaceae (*Aegle, Citrus*), Sapindaceae (*Dimocarpus, Nephelium, Litchi*), Sapotaceae (*Chrysophyllum, Mimusops, Manilkara*), Solanaceae (*Capsicum*), and Tiliaceae (*Muntingia*) (Allwood et al., 1999; CABI, 2007; White and Elson-Harris, 1994)
- *Bactrocera tau* has been reported on hosts in the families Anacardiaceae (*Mangifera indica*); Cucurbitaceae (e.g., *Benincasa hispida, Bryonia laciniosa, Citrullus* spp., *Cucurbita* spp.); Moracea (e.g., *Artocarpus heterophyllus*); Myrtaceae (*Psidium* spp., *Syzygium* spp.); Rutaceae (*Citrus* spp.); Sapotaceae (*Manilkara achras*); Solanaceae (*Solanum lycopersicum*) (Kapoor, 1993; White and Elson-Harris, 1994)

We rated all species **High** for this risk element.

Risk Element #3: Dispersal Potential

Bactrocera fruit flies exhibit high reproductive and dispersal potentials. Total fecundity typically ranges from 500 to 1000 eggs per female, but in the case of *B. dorsalis* may reach more than 3000 eggs per female (Fletcher, 1989a; PPQ, 2002; Weems, 1964a, b). Laboratory studies of *B. dorsalis* and *B. tau* indicate that females can lay up to 40 eggs at one time (Weems, 1964a,b). The number of generations per year varies by species, but all are multivoltine (Lall, 1977; PPQ, 2002; Shi et al., 2005). In warm areas, reproduction is continuous and adults occur throughout the year as hosts are available (CABI, 2011). Adult flight is a major means of dispersal of *Bactrocera* fruit flies to new areas (Hely et al., 1982). Mark-recapture studies have shown that some species of *Bactrocera* are capable of migratory flights of at least 65 km (Fletcher, 1989b). *Bactrocera* fruit flies can also disperse via infested plant materials, such as fruits and flowers (CABI, 2011; Fletcher, 1989b). For example, since 1985, *Bactrocera* spp. have been intercepted at U.S. ports of entry over 12,000 times, in a variety of commodities (PestID, 2012). We rated all four species **High** for this risk element.

Risk Element #4: Economic Impact

Of the tephritid fruit fly genera, *Bactrocera* is generally considered to be one of the most economically significant, and *B. cucurbitae*, *B. dorsalis, and B. tau* are all specifically considered to be species of economic importance (CABI, 2012; Drew et. al., 1979; Kapoor, 1993).

Females puncture fruit and lay their eggs inside the fruit; larvae then hatch and create tunnels as they feed within the fruit. Damaged fruit often becomes predisposed to infection by secondary organisms of decay (e.g., Lall, 1977). Economic losses include 1) downgrading quality caused by oviposition “stings,” which spoil the appearance of fruits, including those unfavorable for larval survival; 2) fruit spoilage caused by larval tunneling and the entry of organisms that cause decay;

Diptera: Tephritidae *Bactrocera cucurbitae, B. dorsalis,* and *B. tau*

3) yield losses due to premature fruit drop, which generally occurs when young fruit are attacked; and 4) indirect damage in the form of lost markets resulting from the imposition of quarantine restrictions (Harris, 1989).

The introduction of *Bactrocera* fruit flies into the continental United States would likely stimulate control programs (CABI, 2011; Orankanok et al., 2007; Vargas et al., 2007). Because they are quarantine pest for numerous countries (EPPO, 2007), an introduction of any of these fruit flies would likely lead to export restrictions of host commodities to markets outside of this pest's known distribution. Economic losses from trade restrictions may be more severe than direct crop losses (Clarke et al., 2005).

All species were rated **High** for this risk element.

Risk Element #5: Environmental Impact

Based on their respective host ranges, some of the species *Bactrocera* analyzed have the potential to feed on Federal Threatened and Endangered plant species occurring in areas climatically suitable survival (because the endangered species are in the same genus as known hosts); however, because *Bactrocera* typically only affect the fruit of its hosts, we assume these fruit flies would have little, if any, direct effect on the population health of endangered plant species. The establishment of a *Bactrocera* fruit fly in the continental United States would probably trigger the initiation of chemical control (CABI, 2011; Mau et al., 2007; Orankanok et al., 2007) and also possibly biological control programs, as has occurred in Hawaii and French Polynesia (Mau et al., 2007; Vargas et al., 2007).

Based on the potential indirect effects of control programs, as opposed to likely direct damage, we rated this risk element **Medium** for all species.

Hemiptera: Coccidae: *Ceroplastes rubens, Drepanococcus cajani, D. chiton, Taiwansaissetia formicarii,* and *Vinsonia stellifera*

Risk Element #1: Climate-Host Interaction

The distribution of *Ceroplastes rubens* extends from warm temperate zones to the tropics. It is found in East and South Asia, throughout Oceania, Australia, East Africa, and the West Indies (CABI, 2011). We estimate that it could survive in U.S. Plant Hardiness Zones 7-11. One or more of its potential hosts occurs in these zones (USDA, 1990). We rated it **High** for this risk element.

The distribution of *Vinsonia stellifera* includes the South Pacific (Australia, Fiji, Ponape Island, Niue, Palau, Papua New Guinea, the Solomon Islands, Tonga), tropical Africa (Angola, Cote d'Ivoire (Ivory Coast), Cape Verde, Kenya, Mauritius, Reunion, Sao Tome and Principe, Seychelles, Tanzania, Zanzibar), Asia (India, Sri Lanka, Malaysia, Pakistan, the Philippines, Thailand, Taiwan, and Vietnam), and tropical America (Brazil, Barbados, Cuba, Grenada, Guyana, Jamaica, Puerto Rico, Trinidad, Virgin Islands). It has also been reported in Alabama, Florida, and Georgia (Hodges, 2002). We estimate that it could survive in U.S. Plant Hardiness Zones 8-11. One or more of its potential hosts occurs in these zones (USDA, 1990). We rated it **High** risk.

Drepanococcus cajani, D. chiton, and *Taiwansaissetia formicarii* are subtropical/tropical pests:

Hemiptera: Coccidae: *Ceroplastes rubens, Drepanococcus cajani, D. chiton, Taiwansaissetia formicarii,* and *Vinsonia stellifera*

- The distribution of *Drepanococcus cajani* includes Hong Kong, India, Sri Lanka, Malaysia, the Philippines, and Taiwan (Ben-Dov et al., 2011).
- The distribution of *Drepanococcus chiton* includes Malaysia, Papua New Guinea, Solomon Islands, Andaman Islands, India, Sri Lanka, Taiwan, Thailand, and Vietnam (Ben-Dov, 1993).
- The distribution of *Taiwansaissetia formicarii* includes Madagascar, Hong Kong, Indonesia, India, Sri Lanka, Malaysia, Thailand, and Taiwan (Ben-Dov et al., 2011).

Based on their distributions, we estimate that these three species could become established in Plant Hardiness Zones 9-11 in the continental United States. One or more of each species' potential hosts occurs in these zones (NRCS, 2011). We rated them **Medium**.

Risk Element #2: Host Range

Coccidae are generally very polyphagous, and all species are rated **High** for this risk element:

- Recorded hosts for *Ceroplastes rubens* include numerous wild and cultivated hosts, such as *Citrus* spp. (Rutaceae), *Mangifera indica* (Anacardiaceae), *Artocarpus altilis* (Moraceae), *Cinnamomum verum* (Lauraceae), *Camellia sinensis* (Theaceae), *Litchi chinensis* (Sapindaceae), *Psidium guajava* (Myrtaceae), *Coffea* sp. (Rubiaceae), *Alpinia purpurata* (Zingiberaceae), *Myristica fragrans* (Myristicaceae), *Annona* sp. (Annonaceae), *Artemisia* sp. (Asteraceae), *Prunus* spp. (Rosaceae), *Pinus* spp. (Pinaceae), *Cocos nucifera* (Arecaceae) (CABI, 2011), and *Psidium guajava* (Sapindaceae) (Ben-Dov et al., 2011; Li-zhong, 2000)
- Recorded hosts for *Drepanococcus cajani* include Convolvulaceae (*Ipomoea*), Fabaceae (*Abrus precatorius*, *Atylosia candollei*, *Cajanus cajan*, *Cajanus indicus*, *Dolichos lablab*, *Pongamia glabra*, *Tephrosia candida*), Lamiaceae (*Coleus, Ocimum* spp.), Myrtaceae (*Psidium guajava*), Rhamnaceae (*Ziziphus* spp.), and Theaceae (*Thea chinensis*)
- The host range of *D. chiton* includes *Semecarpus magnifica* (Anacardiaceae), *Annona muricata* (Annonaceae), *Carica papaya* (Caricaceae), *Calophyllum inophyllum* (Clusiaceae), *Aleurites moluccana* (Euphorbiaceae), *Coleus* (Labiatae), *Litsea* (Lauraceae), *Bauhinia*, *Cajanus indicus*, *Canavalia*, *Cassia*, *Dalbergia*, *Gliricidia septum* (Leguminosae), *Thespesia propulnea* (Malvaceae), *Ficus* (Moraceae), *Grevillea papuana* (Proteaceae), *Colubrina* (Rhamnaceae), *Citrus aurantifolia* (Rutaceae), *Solanum melongena* (Solanaceae), *Theobroma cacao* (Sterculiaceae) (Ben-Dov, 1993), *Ziziphus mauritiana* (Rhamnaceae), *Psidium guajava* (Myrtaceae) (Jothi and Tandon, 1995; Mani and Krishnamoorthy, 1997), and *Averrhoa carambola* (Oxalidaceae) (Ibrahim, 1994)
- Hosts for *Taiwansaissetia formicarii* are in several families including Anacardiaceae (e.g., *Mangifera indica*), Araliaceae (*Heptapleurum octophyllum*) Arecaceae (*Areca* spp., *Kentia macarthurii*, *Ptychosperma macarthurii*, Ebenaceae (*Diospyros* spp.), Fabaceae (*Palaquium formosanum*), Lauraceae (e.g., *Persea americana*), Magnoliaceae (*Michelia* spp.), Moraceae (e.g., *Ficus*), Myrtaceae (e.g., *Psidium guajava*), Rubiaceae (e.g., *Gardenia* spp.), Rutaceae (*Aegle* spp.), Salicaceae (*Salix*), Sapindaceae (*Euphoria longana*), Theaceae (*Camellia* spp.), and Verbenaceae (*Callicarpa formosana*)
- *Vinsonia stellifera* has been reported on hosts in many different families including families such as Anacardiaceae (*Mangifera indica*), Ebenaceae (*Diospyros discolor*),

Hemiptera: Coccidae: *Ceroplastes rubens, Drepanococcus cajani, D. chiton, Taiwansaissetia formicarii,* and *Vinsonia stellifera*
Lauraceae (*Cinnamomum camphora*, *Persea americana*), Leguminosae (*Palaquium* spp.), Liliaceae (*Asparagus sprengeri*), Moreaceae (*Artocarpus integra*, *Ficus* spp.), Musaceae (*Musa*), Myrtaceae (*Psidium guajava*, *Syzygium cumini*), Orchidaceae (*Broughtonia sanguinea*, *Cyripedium niveum*, *Epidendrum ciliare*), Palmae (*Cocos rucifera*, *Nypa*), Polypodiaceae (*Adiantum*), Rubiaceae (*Gardenia* spp., *Ixora*), and Sapotaceae (*Lucuma caimito*) (Hodges, 2002)
Risk Element #3: Dispersal Potential Scales have a relatively high biotic potential (Dekle, 1976). Females may deposit up to 500 eggs (CABI, 2011) and there are usually several generations per year (Kosztarab, 1997). However, the rate of natural dispersal is inherently low (Tandon and Veeresh, 1988) as scales have very limited ability to travel by their own power. The first instar or "crawlers" are the only dispersal stage (Gould and Raga, 2002). The main means of long-distance dispersal is on infested plant materials (CABI, 2011). We rated all these species **Medium** for this risk element.
Risk Element #4: Economic Impact Scales may be found on stems, leaves, and fruit. Like other Coccoidea, they do not normally damage their hosts severely, but large populations cause fruit to become misshapen and deformed, resulting in the fruit being downgraded or unmarketable. Further, the frequent presence of sooty molds on the leaves can affect the appearance of the plant, and also reducing marketability. If extensively present in unmanaged environments, they can impair the phytosynthetic function of leaves (Gould and Raga, 2002; Kwee and Chong, 1990). We rated all these species **Medium**.
Risk Element #5: Environmental Impact The extreme polyphagy of these scales increases the probability that they could be associated with plants in the United States listed as Threatened or Endangered. Plants at risk include those in the families Annonaceae, Anacardiaceae, Euphorbiaceae, Lauraceae, Rhamnaceae, and Rosaceae (e.g., *Manihot walkerae* (Euphorbiaceae), *Ziziphus celata* (Rhamnaceae), *Prunus geniculata* (Rosacea) (USFWS, 2010). Although these scales attack important crops such as citrus, avocado, and pome fruit, they are easily controlled by the same production practices that are already present in the United States to control similar scales. Therefore, it is unlikely that their establishment would trigger the initiation of additional chemical or biological control programs. All species are rated **Medium** for this risk element.

Hemiptera: Monophlebidae: *Icerya aegyptiaca* and *I. seychellarum*
Risk Element #1: Climate-Host Interaction *Icerya aegyptiaca* is distributed in Africa, Oceania, the Middle East, and tropical and subtropical Asia. *Icerya seychellarum* is distributed in Southeast Asia, Eastern and Southern Africa, Australia, and Oceania (CABI, 2011). We estimate that in the United States both species could establish in Plant Hardiness Zones 8-11. One or more of their potential hosts occurs in these zones (NRCS, 2011). We rated them **High** for this risk element.
Risk Element #2: Host Range

Hemiptera: Monophlebidae: *Icerya aegyptiaca* and *I. seychellarum*

Both *Icerya aegyptiaca* and *I. seychellarum* have hosts in many different families. These include *Persea americana* (Lauraceae), *Cocos nucifera* (Arecaceae), *Psidium guajava* (Myrtaceae), *Pyrus* spp., *Rosa* spp. (Rosaceae), *Camellia sinensis* (Theaceae), *Coffea* spp. (Rubiaceae), *Dioscorea* spp. (Dioscoreaceae), *Ipomea batatas* (Convolvulaceae), *Lycopersicum esculentum* (Solanaceae), *Vitis vinifera* (Vitaceae), and *Mangifera indica* (Anacardiaceae) (Ben-Dov et al., 2011). We rated them both **High**.

Risk Element #3: Dispersal Potential

Icerya have a relatively high biotic potential. Males are rare and not necessary for reproduction. For example, female *I. aegyptiaca* typically deposit between 70-140 eggs and complete 2-3 generations per year (Azab et al., 1969). The natural dispersal ability of this pest is, however, inherently low (Tandon and Veeresh, 1988): the first instar or "crawlers" are the only dispersal stage (Gould and Raga, 2002). The main means of long-distance dispersal is on infested plant materials (CABI, 2011). We rated both species **Medium** for this risk element.

Risk Element #4: Economic Impact

Giant mealybugs may be found on stems, leaves, and fruit. Like other Coccoidea, they do not normally damage their hosts severely, but large populations cause fruit to become misshapen and deformed, causing them to be downgraded or unmarketable (Gould and Raga, 2002). Further, the frequent presence of sooty molds on the leaves can affect the appearance of the plant, and also reduce marketability. If extensively present in unmanaged environments, they can impair the phytosynthetic function of leaves (Gould and Raga, 2002; Kwee and Chong, 1990). We rated both species **Medium**.

Risk Element #5: Environmental Impact

The extreme polyphagy of giant mealybugs increases the probability that they could be associated with plants in the United States listed as Threatened or Endangered. Plants particularly at risk include those from the genera *Caesalpinia*, *Crotalaria*, *Eugenia*, *Euphorbia*, *Hibiscus*, *Solanum*, *Prunus*, and *Scaevola* (USFWS, 2010). *Icerya* spp. are easily controlled by the same production practices that are already present in the United States to control similar mealybugs. Therefore, their establishment is unlikely to trigger additional chemical or biological control programs. We rated both **Medium**.

Hemiptera: Pseudococcidae: *Exallomochlus camur, Maconellicoccus hirsutus, Nipaecoccus viridis, Planococcus lilacinus, Pseudococcus cryptus, Rastrococcus spinosus*

Risk Element #1: Climate-Host Interaction

Most of the mealybugs associated with guava in Taiwan have tropical/subtropical distributions.

- *Maconellicoccus hirsutus* is distributed in Northern Africa, parts of sub-Saharan Africa, the Middle East, South and Southeast Asia, the Far East, the Caribbean, Central America, Australia, and Oceania (CABI, 2011). It currently has a limited distribution in the United States, occurring only in Hawaii, California, and Florida (CABI, 2011)
- *Nipaecoccus viridis* is widespread in tropical and subtropical Asia, Africa, and in parts of Oceania (CABI, 2011). It occurs in North America, but its distribution is limited to California and Hawaii (CABI, 2011)
- *Planococcus lilacinus* ranges from south Asia (i.e., Bangladesh, Cambodia, India, Laos, Myanmar, Taiwan, Vietnam, and Yemen) through the islands of the South Pacific (i.e.,

Hemiptera: Pseudococcidae: *Exallomochlus camur, Maconellicoccus hirsutus, Nipaecoccus viridis, Planococcus lilacinus, Pseudococcus cryptus, Rastrococcus spinosus*

Indonesia, Java, Malaysia, the Philippines, and Papua New Guinea) (CABI, 2011). It also occurs in East Africa, Central America, and northern South America (CABI, 2011)

- *Rastrococcus spinosus* is distributed in Bangladesh, Brunei, India, Indonesia, Sumatra, Cambodia, Laos, Malaysia, Pakistan, the Philippines, Singapore, Sri Lanka, Taiwan, Thailand, and Vietnam (Ben Dov et al, 2011)

Based on their distributions, we estimate that these species could establish in areas of the United States corresponding to Plant Hardiness Zones 9-11. One or more of each of these mealybugs' potential hosts occurs in these zones (Kartesz, 2010). We rated the species above **Medium**.

Two of the mealybugs appear to have more temperate distributions:

- *Exallomochlus camur* is distributed in Malaysia, the Philippines, Taiwan, Thailand, and South Korea (Ben Dov et al., 2011)
- *Pseudococcus cryptus* is distributed in Africa (Kenya, Mauritius, Zanzibar); Oceania (American Samoa, Palau, Western Samoa), South America and Central America (Argentina, Brazil, Costa Rica, El Salvador, Paraguay, the U.S. Virgin Islands); and Asia (Bangladesh, Bhutan, China, India, Indonesia, Sumatra, Laos, Malaysia, Nepal, the Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam, Afghanistan, Iran, Israel, Japan, South Korea), and Spain

We estimate that both of these mealybugs could survive in U.S. Plant Hardiness Zones 7-11. One or more of their potential hosts occurs in these zones. We rated them **High** for this risk element.

Risk Element #2: Host Range

Pseudococcidae are generally very polyphagous, and all species are rated **High** for this risk element.

- Hosts of *Exallomochlus camur* include (among others) *Mangifera indica* (Anacardiaceae), Annonaceae (*Annona muricata*), Apocynaceae (*Plumeria robusta*), Arecaceae (*Cocos nucifera*, *Nypa* spp.), Euphorbiaceae (*Antidesma velutinosum*, *Hevea brasiliensis*), Meliaceae (*Lansium domesticum*), Moraceae (*Artocarpus altilis, Artocarpus heterophyllus, Ficus* spp.), *Myrtaceae* (*Eugenia* spp., *Psidium guajava*), Poaceae; Rubiaceae (*Coffea* spp.), and Rutaceae (*Citrus* spp.) (Ben Dov, 2011)
- *Maconellicoccus hirsutus* has been recorded feeding on plants from 73 plant families and over 200 plant genera; it shows some preference for hosts in the families Malvaceae, Leguminosae, and Moraceae (CABI, 2011)
- *Nipaecoccus viridis* has been recorded on hosts distributed among 18 different plant families (CABI, 2011). Primary hosts are species of *Citrus* (Rutaceae), *Coffea* (Rubiaceae), and *Gossypium* (Malvaceae). Other hosts include, among others, *Leucaena leucocephala* (Fabaceae), *Nerium oleander* (Apocynaceae), *Punica granatum* (Punicaceae), *Artocarpus heterophyllus* (Moraceae), *Corchorus capsularis* (Tiliaceae), *Asparagus officinalis* (Liliaceae), *Euphorbia hirta* (Euphorbiaceae), *Mangifera indica* (Anacardiaceae), *Jacaranda mimosifolia* (Bignoniaceae), *Vitis vinifera* (Vitaceae), *Clerodendrum infortunatum* (Verbenaceae), *Solanum tuberosum* (Solanaceae) (CABI, 2011), and *Psidium guajava* (Sapindaceae) (Ben-Dov et al., 2011)
- Hosts of *Planococcus lilacinus* include Anacardiaceae (*Mangifera indica*), Fabaceae (e.g., *Arachis hypogaea*; *Erythrina lithospermum; Tamarindus indica*), Iridaceae (*Gladiolus* spp.), Moraceae (*Ficus* spp.), Moringaceae (*Moringa oleifera)*, Myrtaceae

Hemiptera: Pseudococcidae: *Exallomochlus camur, Maconellicoccus hirsutus, Nipaecoccus viridis, Planococcus lilacinus, Pseudococcus cryptus, Rastrococcus spinosus*

(*Psidium guajava*), Punicaceae (*Punica granatum*), Rhamnaceae (*Zizyphus jujube*), Rubiaceae (*Coffea* spp.), Rutaceae (*Citrus* spp.), Sapotaceae (*Manilkara zapota*), Solanaceae (*Solanum* spp.), and Vitaceae (*Vitis vinifera*)

- Hosts of *Pseudococcus cryptus* include (among others) Adoxaceae (*Viburnum tinus*), Euphorbiaceae (*Hevea brasiliensis*), Fabaceae (*Glycine max*, *Tamarindus indica*), Lauraceae (*Persea americana*), Lythraceae (*Punica granatum*), Malvaceae (*Hibiscus tiliaceus*), Musaceae (*Musa* spp.), Myrtaceae (*Psidium guajava*), Passifloraceae (*Passiflora* spp.), Rubiaceae (*Coffea* spp.), Rutaceae (*Citrus* spp.), Sapindaceae (*Litchi chinensis*), and Vitaceae (*Vitis vinifera*)
- Hosts of *Rastrococcus spinosus* include Anacardiaceae (*Mangifera indica*), Annonaceae (*Annona muricata*), Arecaceae (*Cocos nucifera*, *Nypa* spp.), Clusiaceae (*Garcinia mangostana*), Euphorbiaceae (*Antidesma velutinosum*, *Hevea brasiliensis*), Moraceae (*Artocarpus* spp., *Ficus* spp.), Myrtaceae (*Psidium guajava*), Rubiaceae (*Coffea* spp.), Rutaceae (*Citrus* spp.), and Sapindaceae (*Guioa pleuropteris*)

Risk Element #3: Dispersal Potential

Mealybugs have a relatively high biotic potential. Fecundity varies, but generally ranges between 90-150 eggs, but may be as high as 600 eggs per female in some species. They generally have multiple generations per year. In optimal conditions, *Nipaecoccus viridis*, for example, may have up to 15 generations per year. As with other scales, their natural dispersal ability is inherently low (Tandon and Veeresh, 1988), because the first instar stage, or “crawlers”, is the only dispersal stage (Gould and Raga, 2002). The main means of long-distance dispersal is on infested plant materials (CABI, 2011). We rated all species **Medium** for this risk element.

Risk Element #4: Economic Impact

Mealybugs may be found on stems, leaves, and fruit. Like other Coccoidea, they do not normally damage their hosts severely, but large populations cause fruit to become misshapen and deformed, causing them to be downgraded or unmarketable (Gould and Raga, 2002). Further, the frequent presence of sooty molds on the leaves can affect the appearance of the plant, and also reducing marketability. If extensively present in unmanaged environments, they can impair the phytosynthetic function of leaves (Gould and Raga, 2002; Kwee and Chong, 1990). We rated all six species **Medium** here.

Risk Element #5: Environmental Impact

The extreme polyphagy of these mealybugs increases the probability that they could be associated with plants in the United States listed as Threatened or Endangered. Plants at risk include those in the families Annonaceae, Anacardiaceae, Euphorbiaceae, Lauraceae, Rhamnaceae, and Rosaceae [e.g., *Manihot walkerae* (Euphorbiaceae), *Ziziphus celata* (Rhamnaceae), *Prunus geniculata* (Rosacea)] (USFWS, 2010). Although these mealybugs attack important crops such as citrus, avocado, and pome fruit, they are easily controlled by the same production practices that are already present in the United States to control similar insects. Therefore, their establishment is unlikely to trigger the initiation of additional chemical or biological control programs. We rated all of them **Medium** for this risk element.

Lepidoptera: Noctiuidae: *Helicoverpa armigera*

Risk Element #1: Climate-Host Interaction

This moth occurs in Western and Eastern Europe, Siberia, Far East, Asia, Africa, Oceania

Hemiptera: Pseudococcidae: *Exallomochlus camur, Maconellicoccus hirsutus, Nipaecoccus viridis, Planococcus lilacinus, Pseudococcus cryptus, Rastrococcus spinosus*
(CABI, 2011). We estimate that this species could establish within U.S. Plant Hardiness Zones 4–11. We rated it **High** for this risk element.
Risk Element #2: Host Range *Helicoverpa armigera* is polyphagous. It infests crop and non-crop hosts representing over 10 genera in more than four families (Zhang, 1994). It is a major pest of cotton (*Gossypium* spp.), pigeon pea (*Cajanus cajan*), chickpea (*Cicer arietinum*), tomato (*Lycopersicum esculentum*), sorghum (*Sorghum* spp.), and cowpea (*Vigna unguiculata*). Other hosts include groundnut (*Arachis hypogaea*), eggplant (*Solanum melongena*), peas (*Pisum sativum*), soybeans (*Glycine max*), other legumes, tobacco (*Nicotiana tabacum*), potatoes (*Solanum tuberosum*), maize (*Zea mays*), flax (*Linum usitatissimum*), a number of fruits (*Prunus* spp. and *Citrus* spp.), forest trees, and a range of vegetable crops (CABI, 2011). Because it attacks multiple hosts in multiple families, we rated it **High** for this risk element.
Risk Element #3: Dispersal Potential Internal larvae may be dispersed by fruits (CABI, 2011). Females may lay over 700 eggs during their lifetime; there may be up to six generations per year (CABI, 2011), with two to six generations depending on the climatic conditions. Larvae have limited mobility, but adults can fly (CABI, 2011). Because of its high biotic potential and ability to disperse well naturally, we rated it **High**.
Risk Element #4: Economic Impact Larvae are major pests of tomato, maize, cotton, and other crops that could become major hosts if this pest establishes (CABI, 2011). For example, in India, losses of up to 50 percent of the potato crop have been recorded (CABI, 2011). Several larvae on a single cotton plant will devour all of the bolls within two weeks (Lammers and MacLeod, 2007). Feeding by larvae can reduce yields of tomato fruit and maize kernels (Lammers and MacLeod, 2007). An infestation on *Pinus radiata* in New Zealand resulted in 60 percent of the trees losing 50 percent of their foliage (Lammers and MacLeod, 2007). *Helicoverpa armigera* is listed as an A2 quarantine pest by the European Plant Protection Organization (EPPO) and considered a quarantine pest by the Caribbean Plant Protection Commission (CPPC), Organismo Internacional Regional de Sanidad Agropecuaria (OIRSA), and the country of Brazil (EPPO, 2007). We rated this pest **High** for economic impact.
Risk Element #5: Environmental Impact A wide range of wild plant species support larval development of *H. armigera*. Larvae can feed on the genera *Allium*, *Amaranthus*, *Helianthus*, *Helianthus*, *Prunus*, *Solanum*, and *Vigna* (CABI, 2011), which contain Threatened or Endangered species (USFWS, 2010). Because it represents a potential threat to important crop industries, the establishment of *C. punctiferalis* in the United States could trigger the initiation of eradication or chemical/biological control programs, similar to those that have occurred elsewhere (CABI, 2011). We rated it **High** for this risk element.

Lepidoptera: Pyralidae: *Conogethes punctiferalis*
Risk Element #1: Climate-Host Interaction *Conogethes punctiferalis* is a cosmopolitan species in warm climates. It is currently found in Australia (Northern Territory, Queensland, Northern New South Wales), India, China, Japan, and

Lepidoptera: Pyralidae: *Conogethes punctiferalis*
Indonesia (CABI, 2011). Based on this distribution we estimate that *C. punctiferalis* could establish in Plant Hardiness Zones 7-11 in the United States. One or more of its potential hosts occurs in these zones (NRCS, 2011). We rated this pest **High**.
Risk Element #2: Host Range *Conogethes punctiferalis* is polyphagous, and often encountered on commercial crops (CABI, 2010). Hosts include citrus (*Citrus* spp.), avocado (*Persea americana*), grapes (*Vitis* spp.), pomegranate (*Punica granatum*), rice (*Oryza sativa*), cotton (*Gossypium* spp.), garlic (*Allium sativum*), beans (*Phaseolus* spp.), coffee (*Coffea* spp.), maize (*Zea mays*), mango (*Mangifera indica*), guava (*Psidium guajava*), and sugarcane (*Saccharum officinarum*) (CABI, 2010). Consequently, we rated it **High risk** for this element.
Risk Element #3: Dispersal Potential *Conogethes punctiferalis* has a relatively high biotic potential. Two to three days after mating, females start to lay eggs on the surface of fruits. Each female lays 20-30 eggs. Eggs hatch 5-8 days after oviposition, and the hatching rate may reach 100 percent. *Conogethes punctiferalis* has up to five generations per year (CABI, 2011). Like other species of Pyralidae, *C. punctiferalis* is capable of long distance flight (Showers et al., 2001), but we also although it would not tend to not disperse out of favorable habitats (Cohen et al., 2000; Qureshi et al., 2005). Additionally, *C. puncterferalis* can be dispersed by infested plant materials, such as fruits and seeds. For example, since 1985, species of *Conogethes* have been intercepted at U.S. ports of entry in a variety of commodities (including *Prunus*) over 700 times (PestID, 2012). We rated it **High** for this element.
Risk Element #4: Economic Impact *Conogethes punctiferalis* is an important pest of citrus (*Citrus* spp.), grapes (*Vitis* spp.), and pomegranates (*Punica granatum*) in the Mediterranean (CABI, 2007). It is most noted as a pest of avocado (*Persea americana*) in Israel, of azolla (*Azolla* sp.), sorghum (*Sorghum* spp.), and rice (*Oryza sativa*) in India, and sporadically of corn (*Zea mays*) or other crops in any warm part of the world (CABI, 2011). The losses caused by this pest have not been quantified. Because *C. gnidiella* affects some important export crops (including citrus, cotton, beans, grapes, etc.) its presence in the United States, even as a temporary adventive population, could lead to severe export restrictions of host commodities to markets outside of this pest's known distribution. We rated it **High**.
Risk Element #5: Environmental Impact *Conogethes punctiferalis* could damage Federally listed Threatened and Endangered species, such as *Prunus genuclata* (FL). This species is closely related to other hosts known to be attacked by *C. punctiferalis* (USFWS, 2010). Because it threatens *Citrus*, stone fruit, and other important crop industries, the establishment of *C. punctiferalis* in the United States could trigger the initiation of eradication or chemical/biological control programs, similar to those that have occurred elsewhere (CABI, 2011). Thus, we rated it **High** for this risk element.

Thysanoptera: Thripidae: *Rhipiphorothrips cruentatus*

Thysanoptera: Thripidae: *Rhipiphorothrips cruentatus*

Risk Element #1: Climate-Host Interaction

Rhipiphorothrips cruentatus is reported as widespread in India and Sri Lanka and also present in Afghanistan, Bangladesh, China (Guangdong, Hainan), Taiwan, Myanmar, Oman, Pakistan, and Thailand (CABI, 2011). Based on this distribution, it is estimated that this species could become established in the continental United States in areas corresponding to Plant Hardiness Zones 8-11. One or more of its potential hosts occurs in these zones (NRCS, 2011). This pest is rated **Medium** for this element.

Risk Element #2: Host Range

Rhipiphorothrips cruentatus is polyphagous, and its primary hosts include *Anacardium occidentale* (Anacardiaceae), *Annona squamosa* (Annonaceae), *Mangifera indica* (Anacardiaceae), *Psidium guajava* (Myrtaceae), *Punica granatum* (Punicaceae), *Rosa rugosa* (Rosaceae), *Syzygium cumini* (Myrtaceae), *Syzygium samarangense* (Myrtaceae), *Terminalia catappa* (Combretaceae), and *Vitis vinifera* (Vitaceae) (CABI, 2011). Because this pest attacks hosts in multiple genera and families, we rated it **High** for this element.

Risk Element #3: Dispersal Potential

Rhipiphorothrips cruentatus can reproduce sexually or by parthenogenesis (CABI, 2011; Chiu, 1984). In field and laboratory studies on wax apple in Taiwan, females laid approximately 13 eggs, which hatched in 13 days, and nymphs reached adulthood in 12.5 days (Chiu, 1984). Five to eight generations occur each year in India, and overwintering pupae emerge from the soil as adults in March (Butani, 1979). In contrast, *R. cruentatus* reproduces throughout the year in Taiwan without a diapause (CABI, 2011). Adults can fly and their small size and fringed wings allow long-distance dispersal via wind or as passengers in commercial commodities (Lewis, 1997). Because this pest has both a high reproductive potential and high dispersal potential, we rated it **High** for this risk element.

Risk Element #4: Economic Impact

Rhipiphorothrips cruentatus is a major thrips pests in Taiwan (Chang et al., 1995), where it attacks wax apple (*Syzygium samarangense*) (CABI, 2011) and roses (Wang and Wang, 1997). It also damages other crops, such as mango and guava, causing yield reductions and loss of market value (CABI, 2011). It is an important pest of grapes, roses (CABI, 2011) and guava (Harmit et al., 2001) in India.Attack by this thrips causes the host's leaves to turn brown and to fall prematurely (CABI, 2011). It can also cause fruit damage. For example, in India, damage to guava fruit was reported to range from 10 to 57 percent (Gima et al., 2001). Introduction of this pest into the United States could cause a loss of foreign and domestic markets, but direct damage is likely to be limited since it is controlled by the same production practices in place for similar thrips that are already present in the United States. We rated this pest **Medium**.

Risk Element #5: Environmental Impact

None of the genera containing primary hosts of *R. cruentatus* are listed as Threatened or Endangered in 50 CFR §17.12. However, plants in families containing primary hosts of *R. cruentatus* (e.g., Anacardiaceae, Annonaceae, and Rosaceae) are listed as Threatened or Endangered (e.g., *Rhus michauxii, Asimina tetramera,* and *Potentilla hickmanii*). Since we have njo information on preference tests for these plants and *R. cruentatus*, we assumed that one or more of these plants could be a host. Although this thrips attacks grapes and other possible commercial crops, it is easily controlled by the same production practices that are already present in the United States to control other thrips. Therefore, its establishment is unlikely to trigger the initiation of additional chemical or biological control programs. We rated it **Medium**.

Ascomycetes: Xylariales: *Pestalotiopsis psidii*

Risk Element #1: Climate-Host Interaction

The geographic distribution of *P. psidii* includes Australia, Burma, India, Bangladesh, Nepal, Malaysia, Taiwan, Mozambique, Nigeria, Zambia, Zimbabwe, Italy, Puerto Rico, Mexico (Aguascalientes, Zacatecas), Ecuador, Venezuela, and Brazil (Tsay, 1991; Hossain and Meah, 1992; Cardoso et al., 2002; González et al., 2002; Lim and Manicom, 2003; Farr et al, 2010). Based on this subtropical to tropical distribution, we estimate this pathogen could establish in Plant Hardiness Zone 10 in the United States, and perhaps in some areas of zone 9, depending on adjacent climate areas and cultural practices. Accordingly, the rating is **Med**.

Risk Element #2: Host Range

Recorded hosts include *Feijoa sellowiana*, *Psidium* spp. (Myrtaceae), and *Musa paradisiaca* (Musaceae) (Farr et al, 2010). These hosts are available only in South Florida. This pest has a very limited host distribution and we found no evidence of other host associations. Consequently, the risk for this element is **Low**.

Risk Element #3: Dispersal Potential

Pestalotiopsis psidii is a weak pathogen, normally occurring as an endophyte in the woody tissues of twigs. It invades fruits opportunistically through insect injuries (Lim and Manicom, 2003), indicating a low degree of virulence. Conditions for local spread of the pathogen are optimal during periods of high precipitation (>130 mm), relative humidity of at least 77 percent, and an average temperature of 23ºC (González et al., 2002). Spread is associated with rainsplash (Lim and Manicon, 2003). Rainsplash is usually considered to have a maximum of a few kilometers under near hurricane conditions but is typically on the order of tens of meters to a few hundred meters. Although long-distance dispersal is possible, it is rare. We rated this pest **Medium.**

Risk Element #4: Economic Impact

Use of fungicides provides effective control of the pathogen (e.g., Tsay, 1991; Hossain and Meah, 1992; González et al., 2002), but increases production costs (Ribeiro and Pommer, 2004). The fruit lesions caused by *P. psidii* (Lim and Manicom, 2003) also could result in a downgrading of fruit quality and divert the commodity from the more lucrative fresh-fruit market into lower value end uses, such as juice. However, the two economic hosts of the fungus, guava and banana are not grown extensively in the Continental United States. The risk of this pest for economic impact is **Low**.

Risk Element #5: Environmental Impact

This pathogen is unlikely to pose a threat to native plants in the United States. No close relatives of its known hosts listed in 50 CFR §17.12 are present. Measures (e.g., application of broad-spectrum fungicides) already employed to control fungal pathogens of guava or other hosts probably would be equally effective against *P. psidii* were it to become established. For this reason, we rated the risk **Low**.

Table 5. Summary of the Risk Ratings and the value for the Consequences of Introduction.

Pest	**Climate/ Host**	**Host Range**	**Dispersal Potential**	**Economic Impact**	**Environ-mental Impact**	**Consequences of Introduction value**[1]
Bactrocera cucurbitae	High (3)	High (3)	High (3)	High (3)	Medium (2)	High (14)
Bactrocera dorsalis	Medium (2)	High (3)	High (3)	High (3)	Medium (2)	High (13)
Bactrocera tau	Medium (2)	High (3)	High (3)	High (3)	Medium (2)	High (13)
Ceroplastes rubens	High (3)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (12)
Conogethes punctiferalis	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Drepanococcus cajani	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (11)
Drepanococcus chitón	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (11)
Eutetranychus orientalis	Medium (2)	High (3)	Medium (2)	High (3)	Medium (2)	Medium (12)
Exallomochlus camur	High (3)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (12)
Helicoverpa armigera	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Icerya aegyptiaca	High (3)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (12)
Icerya seychellarum	High (3)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (12)
Maconellicoccus hirsutus	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (11)
Nipaecoccus viridis	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (11)
Oligonychus biahrensis	Medium (2)	High (3)	Medium (2)	High (3)	Medium (2)	Medium (12)
Oligonychus litchi	Medium (2)	High (3)	Medium (2)	Medium (2)	Low (1)	Medium (10)
Pestalotiopsis psidii	Med (2)	Low (1)	Medium (2)	Low (1)	Low (1)	Low (7)
Planococcus lilacinus	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (11)
Pseudococcus cryptus	High (3)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (12)
Rastrococcus spinosus	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (11)
Rhipiphorothrips cruentatus	Medium (2)	High (3)	High (3)	Medium (2)	Medium (2)	Medium (12)
Taiwansaissetia formicarii	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (11)
Vinsonia stellifera	High (3)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (12)

[1] Low is 5-8 points, Medium is 9-12 points and High is 13-15 points

2.5.2. Likelihood of Introduction—Quantity Imported and Pest Opportunity

Likelihood of introduction is a function of both the quantity of the commodity imported annually and pest opportunity, which consists of five criteria that consider the potential for pest survival along the pathway (USDA, 2000). The values determined for the Likelihood of Introduction for each pest are summarized below (Table 6).

Quantity of commodity imported annually. The rating for the quantity imported annually usually is based on the amount reported by the exporting country, converted into standard units of 40-foot-long shipping containers. We do not know the amount of guava that will be exported annually from Taiwan, but it is not expected to exceed 100 containers per year. Therefore, we rated all pests **Medium** for this subelement.

Survive post-harvest treatment. In this subelement we evaluate the efficacy of post-harvest treatments in terms of the mortality of pests exposed to the treatments. Among the arthropod pests, the tephritid fruit flies (*Bactrocera cucurbitae, B. dorsalis,* and *B. tau*) and Lepidoptera (*Helocoverpa armigera* and *Conogethes punctiferalis*), as internal feeders, are likely to survive these post-harvest treatments. That is especially true if infestations are so young that the damage is not obvious. We rated these six pests **High** for this risk element.

Scale insects (Coccidae, Maragodidae, and Pseudococcidae) have sessile stages that live firmly pressed to plant surfaces. The cryptic behavior and small size of the scales insects and mealybugs in the families Coccidae and Pseudococcidae along with their water-repellent, waxy coverings, and firm attachment to the substrate could make them difficult to see or dislodge, especially if sheltered at the stem end of the fruit. For example, many scales prefer tight, protected areas, such as cracks and crevices (Kosztarab, 1996). According to Gould and Raga (2002) bagging fruits to protect them from fruit flies actually benefits mealybugs, protecting them from predators and parasites and forming a favorable microclimate inside the bag. We rated the pests in these families—Coccidae: *Ceroplastes rubens, Drepanococcus cajani, D. chiton, Taiwansaissetia formicarii,* and *Vinsonia stellifera*; Pseudococcidae: *Exallomochlus camur, Maconellicoccus hirsutus, Nipaecoccus viridis, Planococcus lilacinus, Pseudococcus cryptus, Rastrococcus spinosus*—**Medium** for this subelement.

The giant mealybugs *Icerya aegyptiaca* and *I. seychellarum* are much larger and more conspicuous than other Coccoidea. They are highly likely to be removed during culling, so we rated them **Low**.

Eutetranychus orientalis, *Oligonychus biharensis*, and *O. litchi* are external pests, and therefore are generally visible upon inspection, particularly for large infestations (usually true if found on fruit) or if webbing is present. Additionally, damage by these mites generally causes detectable symptoms (Avidov and Harpaz, 1969; Gould and Raga, 2002; van den Berg et al., 2001). They are small, however, so if concealed beneath the calyx, present in the egg stage, or in very low numbers, these organisms would be difficult to detect. Consequently, we rated them **Medium**.

Rhipiphorothrips cruentatus adults are dark brown and, therefore, easy to detect on leaves and fruit (CABI, 2011); however, the larvae and eggs of *R. cruentatus* would be more difficult to detect. Consequently it is rated **Medium** for this risk element.

The fungi are likely to survive post-harvest treatment. *Pestalotiopsis psidii* invades the fruit epidermis, eventually producing a scabby lesion on the fruit surface (Horst, 2001; Lim and Manicom, 2003). As internal pathogens, the fungi would be protected from any post-harvest operations that treat the fruit surface only. These internal infections and latent infections are likely to survive any post-harvest treatments, thus the risk rating is **High.**

Survive shipment. Specific shipping conditions were not specified or assumed in this risk assessment. To maintain the quality of guava fruits [which are sensitive to chilling injury at 2 ^{o}C (36 ^{o}F)], the recommended temperature for transport and storage is 5-10^{o}C (41-50 ^{o}F) with 85-90% relative humidity (McGregor, 1987). If properly packaged and held close to the recommended storage temperature and relative humidity, the time available for transit and storage is estimated to be two to three weeks (McGregor, 1987). We estimate these environmental conditions and time frames are unlikely to reduce population levels of the quarantine pests of concern.

Further, once fruit are infected with *P. psidii,* the infection cannot be removed. *Pestalotiopsis psidii* has been known to survive in dead leaves and twigs, so even desiccated fruit could have viable pathogen (Zengzhoung, 2005). We found no evidence that prolonged low or high temperatures could kill the fungus, although they could stall its development. Therefore, we estimated that the unmitigated (i.e., absence of any specific quarantine treatment during shipment) risk of each of these pests surviving shipment is **High**.

Not detected at a port-of-entry. The larvae of the tephritid fruit flies are internal pests. The fruit flies deposit their eggs under the surface of the fruit. The early stages of larval development inside the fruit are only adequately detected by destructive sampling. Depending on the age of infestation, these pests could be highly likely to escape detection. In fact, fruits infested with fruit flies often go unrecognized (White and Elson-Harris, 1994). We rated *Bactrocera cucurbitae, B. dorsalis,* and *B. tau* **High** for this subelement.

The Lepidopteran larvae are also internal pests. *Helocoverpa armigera* and *Conogethes punctiferalis* larvae enter fruit by chewing through the surface, creating an opening that may have frass associated with it (CABI, 2011). The injury also makes the fruit more susceptible to rots and secondary pests. The entry holes of second instar and larger larvae will generally be visually obvious. The entry hole and injury associated with first instar larvae may be difficult to detect on some fruit, especially when hidden by the calyx or stem. We rated these two pests **Medium**.

As external pests, the mites (*E. orientalis* and *Oligonychus* spp.) could be visually detected during port inspection, particularly if population sizes are relatively high (CABI, 2011). Also, damage by these mites can cause detectable symptoms. At low population densities, though, the minute arthropods could be concealed under the calyx, and may escape detection using standard visual inspection. Therefore, we rated them **Medium** for this subelement.

Because of the small size of the scales (Coccidae) and mealybugs (Pseudococcidae) and their sessile nature, low population densities of these arthropods may escape detection, particularly if concealed at the stem end of fruits or in packing materials (CABI, 2011). In contrast, the large size of the giant mealybug (Maragodidae) makes it much less likely that these pests would escape detection. Therefore, we rated the giant mealybugs, *Icerya* spp., **Low**. We rated Medium all of the following scales: *Ceroplastes rubens, Drepanococcus cajani, D. chiton, Taiwansaissetia formicarii,* and *Vinsonia stellifera* and the mealybugs *Exallomochlus camur, Maconellicoccus hirsutus, Nipaecoccus viridis, Planococcus lilacinus, Pseudococcus cryptus,* and *Rastrococcus spinosus*.

The adults of the thrips *Rhipiphorothrips cruentatus* are dark brown and therefore tend to be easily detected during quarantine inspections (CABI, 2011). The larvae and eggs of *R. cruentatus*, however, would be more difficult to detect. Consequently, we rated it **Medium**.

The scab produced in fruit infections by *Pestalotiopsis psidii* is readily apparent to the naked eye (Zengzhoung, 2005). The latent stage of infection and any infection which fails to produce or has not yet a surface lesion is undetectable at a port. The likelihood that some fruit would escape detection is **Medium.**

Moved to a habitat suitable for survival. In this sub-element we consider the geographic location of likely markets and the chance that the commodity will be moved to locations suitable for pest survival. Fruit imported into the United States typically arrives at multiple ports and is distributed according to market demand. Demographics derived from U.S. Census data may be useful in predicting the distribution of imported guava fruit by indicating population centers where demand may be greatest. Three of the four most heavily populated States in the United States, Florida, Texas, and California, have climates that closely resemble the native climates of the pests analyzed. All of the arthropod pests analyzed are likely to be able to establish in U.S. Plant Hardiness Zones 9-11, where approximately 26 percent of the U.S. population resides. Therefore, we rated all arthropods **High** for this subelement.

In contrast, the only viable habitat for the pathogen *Pestalotiopsis psidii* is in Miami/Dade County, Florida (see above). Since this area is so small and the distribution of guava within the county is limited, the risk of infected fruit being moved to a suitable area is **Low**.

Come into contact with host material suitable for reproduction. Even if the final destination of infested commodities is suitable for pest survival, suitable hosts must be available in order for the pest to survive. In this sub-element, we consider the likelihood that the pest species can come in contact with host material for reproduction. The complete host range of the pest was considered. According to the IPPC standard for pest risk analysis (IPPC, 2003), other factors that may be considered are:

- Dispersal mechanisms, including vectors to allow movement from the pathway to a suitable host
- Whether the imported commodity is to be sent to a few or many destinations in the PRA area
- Proximity of entry, transit and destination points to suitable hosts
- Time of year at which import takes place
- Intended use of the commodity (e.g., for planting, processing or consumption)
- Risks from by-products and waste

All of the arthropods we analyzed are polyphagous species and hosts include temperate-zone or widely cultivated plants (USDA NRCS, 2003) that should be available throughout their potential U.S. range.

Taiwan harvests guava from April through July and September through November (BAPIQ, 2009) and it assumed that guava fruit would be shipped to the United States during these months. Suitable hosts would be available throughout the shipping season in the southern States and would be available during most of the shipping season in the rest of the United States.

Even if hosts are available for colonization, biological attributes of the organisms influence the probability of finding these hosts and successfully establishing in the United States. The sessile nature of scale and mealybug insects and mites would severely limit their chances of coming into contact with hosts (Gullan and Kosztarab, 1997). Successful establishment of these insects in a new environment can occur only when mobile forms (i.e., crawlers) are present on the imported fruit and these fruit are placed in close proximity to a susceptible host. As these circumstances are highly unlikely to co-occur, scale and mealybug insects have a **Low** probability of establishment on fruits for consumption.

The thrips, *Rhipiphorothrips cruentatus*, and the mites (*Eutetranychus orientalis*, *Oligonychus biahrensis*, and *Oligonychus litchi*) have some natural ability to disperse, although limited. We rated them **Medium** for this subelement.

Bactrocera spp. have excellent dispersal capabilities, and many of them can fly 50-100 km during their life (Fletcher, 1989b). Adult *Helocoverpa armigera* and *Conogethes punctiferalis* are generally good flyers as well, and can fly long distances (CABI, 2011). Tephritid fruit flies (*Bactrocera cucurbitae*, *B. dorsalis*, and *B. tau*) and the Lepidoptera (*Helocoverpa armigera* and *Conogethes punctiferalis*) are rated **High** for this risk element.

We rated the pathogen, *Pestalotiopsis psidii*, **Low**, because, as discussed above, the endangered area is so small and the distribution of guava within the county is limited.

Table 6. Risk ratings for likelihood of introduction (guava, *Psidium guajava*).

Pest	Quantity imported annually	Survive post-harvest treatment	Survive shipment	Not detected at port of entry	Moved to suitable habitat	Contact with host material	Cumulative risk rating
Bactrocera cucurbitae	Med (2)	High (3)	High (3)	High (3)	High (3)	High (3)	High (17)
Bactrocera dorsalis	Med (2)	High (3)	High (3)	High (3)	High (3)	High (3)	High (17)
Bactrocera tau	Med (2)	High (3)	High (3)	High (3)	High (3)	High (3)	High (17)
Ceroplastes rubens	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Conogethes punctiferalis	Med (2)	High (3)	High (3)	Med (2)	High (3)	High (3)	High (16)
Drepanococcus cajani	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Drepanococcus chitón	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Eutetranychus orientalis	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Med (2)	Medium (14)
Exallomochlus camur	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Helicoverpa armigera	Med (2)	High (3)	High (3)	Med (2)	High (3)	High (3)	High (16)
Icerya aegyptiaca	Med (2)	Low (1)	High (3)	Low (1)	High (3)	Low (1)	Medium (11)
Icerya seychellarum	Med (2)	Low (1)	High (3)	Low (1)	High (3)	Low (1)	Medium (11)
Maconellicoccus hirsutus	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Nipaecoccus viridis	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Oligonychus biahrensis	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Med (2)	Medium (14)
Oligonychus litchi	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Med (2)	Medium (14)
Pestalotiopsis psidii	Med (2)	High (3)	High (3)	Med (2)	Low (1)	Low (1)	Medium (12)
Planococcus lilacinus	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Pseudococcus cryptus	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Rastrococcus spinosus	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Rhipiphorothrips cruentatus	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Med (2)	Medium (14)

Pest	Quantity imported annually	Survive post-harvest treatment	Survive shipment	Not detected at port of entry	Moved to suitable habitat	Contact with host material	Cumulative risk rating
Taiwansaissetia formicarii	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)
Vinsonia stellifera	Med (2)	Med (2)	High (3)	Med (2)	High (3)	Low (1)	Medium (13)

[1] Low is 6-9 points, Medium is 10-14 points, and High is 15-18 points

2.5.3. Conclusion: Pest Risk Potential

Summation of the Consequences of Introduction and the Likelihood of Introduction values produce the Pest Risk Potential (Table 7). The following scale is used to interpret the Pest Risk Potential: Low is 11-18 points, Medium is 19-26 points, and High is 27-33 points. Pest Risk Potential is a baseline estimate of the risks associated with importation of the commodity in the absence of mitigation measures.

Specific phytosanitary measures beyond port-of-entry inspection may be necessary for pests with a Pest Risk Potential of Medium. On the other hand, specific phytosanitary measures are strongly recommended for pests rated High as port-of-entry inspection is not considered sufficient to provide phytosanitary security.

Table 7. Pest Risk Potential.

Pest	Consequences of Introduction	Likelihood of Introduction	Pest Risk Potential
Bactrocera cucurbitae	High (14)	High (17)	High (31)
Bactrocera dorsalis	High (13)	High (17)	High (30)
Bactrocera tau	High (13)	High (17)	High (30)
Ceroplastes rubens	Medium (12)	Medium (13)	Medium (25)
Conogethes punctiferalis	High (15)	High (16)	High (31)
Drepanococcus cajani	Medium (11)	Medium (13)	Medium (24)
Drepanococcus chitón	Medium (11)	Medium (13)	Medium (24)
Eutetranychus orientalis	Medium (12)	Medium (14)	Medium (26)
Exallomochlus camur	Medium (12)	Medium (13)	Medium (25)
Helicoverpa armigera	High (15)	High (16)	High (31)
Icerya aegyptiaca	Medium (12)	Medium (11)	Medium (23)
Icerya seychellarum	Medium (12)	Medium (11)	Medium (23)
Maconellicoccus hirsutus	Medium (11)	Medium (13)	Medium (24)
Nipaecoccus viridis	Medium (11)	Medium (13)	Medium (24)
Oligonychus biahrensis	Medium (12)	Medium (14)	Medium (26)
Oligonychus litchi	Medium (10)	Medium (14)	Medium (24)
Pestalotiopsis psidii	Low (7)	Medium (12)	Medium (19)
Planococcus lilacinus	Medium (11)	Medium (13)	Medium (24)
Pseudococcus cryptus	Medium (12)	Medium (13)	Medium (25)

Pest	Consequences of Introduction	Likelihood of Introduction	Pest Risk Potential
Rastrococcus spinosus	Medium (11)	Medium (13)	Medium (24)
Rhipiphorothrips cruentatus	Medium (12)	Medium (14)	Medium (26)
Taiwansaissetia formicarii	Medium (11)	Medium (13)	Medium (24)
Vinsonia stellifera	Medium (12)	Medium (13)	Medium (25)

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Appendix A: Pest Risk of Armored Scale Insects (Hemiptera: Diaspididae)

Armored scales *Aonidiella aurantii* (Maskell), *A. comperei* (McKenzie), and *Octaspidiotus stauntoniae* (Takahashi) are quarantine pests associated with guava fruit and present in Taiwan. Although they may be able to follow the pathway of guava fruit from Taiwan, and enter the United States, these scales would be highly unlikely to come in contact with host material via this pathway and, therefore, are highly unlikely to be able to establish in the United States. Evidence to support this conclusion includes the following.

- Scale insects (Coccoidea), including armored scales, may disperse great distances by wind (Greathead, 1990; Greathead, 1997; Gullan and Kosztarab, 1997). They do not have the capability for directed dispersal in this way, so long range dispersal would depend on the dispersal of large numbers of insects so that some may find suitable hosts. Insects arriving with commercial quality fruit represent such small populations that dispersal by air to a host would be very unlikely.
- The newly emerged first instar nymphs ("crawlers") of scale insects are capable of dispersing long distances by wind (Gullan and Kosztarab, 1997). For armored scales, "only crawlers and perhaps gravid females could contribute to dispersal of the species and to the colonization of new host plants" (Greathead, 1990). The crawler stage is the primary stage where upon dispersal is possible, because this is the only mobile stage besides the adult male (Greathead, 1990; Koteja, 1990). Although adult males are mobile, they cannot start new infestations by themselves (Greathead, 1990; Koteja, 1990). Based on this evidence, the spread of armored scales from infested plant materials for consumption can only occur if crawlers or adult females with eggs are present (Burger and Ulenberg, 1990), and spread from the gravid females likely would occur only if crawlers hatched from the females' eggs.
- Although crawlers may disperse long distances by wind (as explained above), and can theoretically walk a distance of up to 150 m, they "usually settle within several dozen cm of their birth site" (Koteja, 1990).
- The crawler stage of armored scale insects occurs for a relatively short time (Koteja, 1990); this stage is divided into four periods: 1) postnatal torpidity, which lasts a few minutes to several hours, depending on ecological factors; 2) dispersal phase; 3) feeding period; and 4) morphogenetic period (Koteja, 1990). Crawlers are mobile only during the dispersal phase, which lasts in general several hours to several days (Koteja, 1990). For example, in one study, the wandering time of *Aonidiella aurantii* lasted from 174 to 206 minutes (approximately 3 to 3.5 hours) (Greathead, 1990). Studies with *A. aurantii*, as well as other armored scale species, show that most crawlers will terminate wandering and settle on a host within 24 hours of emergence (Greathead, 1990). Due to the brevity of the crawler stage, the stage most capable of dispersal (as described above), the likelihood of establishment of armored scales via imported fruit for consumption further decreases.
- A USDA Agricultural Research Service expert working group assessed the risk of armored scales on fruit for consumption (Miller et al., 1985). These authors concluded that, for several reasons, the probability of armored scales' establishment in a new region, by way of commercially shipped fruit for consumption, is relatively remote. These authors state that fruits are not the preferred feeding sites for most armored scales;

> therefore, these insects would be less likely to survive on fruits compared to leaves or twigs. Secondly, the sessile nature of armored scales and their inability to disperse long distances under their own powers severely limit their ability of coming into contact with potential hosts. Furthermore, for armored scales on imported commercial fruit to establish in a new area, many conditions must co-occur, which is highly unlikely. These conditions include 1) survival through harvest and post-harvest handling and transport; 2) survival of the rigors of the marketplace, as well as consumer storage, handling, and consumption; 3) presence of a susceptible host near infested fruit discarded by the consumer; 4) presence of crawlers on the discarded fruit (or the fruit stays viable long enough for crawlers to develop from a gravid female); and 5) successful colonization of the new host by the crawlers (Miller et al., 1985).

The evidence above was an important consideration for the decision to make scale insects on commodities for consumption non-actionable at U.S. ports of entry, and is the reason that these pests were not analyzed further.