Movement of Cowpea, and its relatives (*Vigna unguiculata* (L.) Walp), as Fresh Immature Fruit Pods from Hawaii into the Continental United States

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Executive Summary

This risk assessment document examines the risks associated with the importation of *Vigna unguiculata* (L.) Walp (cowpea, sow-pea, asparagus-bean, pea-bean, yard-long bean, black-eyed pea, croweder-pea, southern-pea) from Hawaii into the continental United States. Information on pests associated with *Vigna unguiculata* in Hawaii revealed that 11 quarantine pests (all of which are arthropods) exist and could be introduced into the United States via this pathway.

The following species are High risk:

Bactrocera cucurbitae (Diptera: Tephritidae)
Frankliniella schultzei (Thysanoptera: Thripidae)
Lampides boeticus (Lepidoptera: Lycaenidae)
Maruca vitrata (Lepidoptera: Pyralidae)
Spodoptera litura (Lepidoptera: Noctuidae)
Thrips palmi (Thysanoptera: Thripidae)

The following species are Medium risk:

Aleurodicus dispersus (Hemiptera: Aleyrodidae)
Cryptophlebia ombrodelta (Lepidoptera: Tortricidae)
Dysmicoccus neobrevipes (Homoptera: Pseudococcidae)
Maconellicoccus hirsutus (Homoptera: Pseudococcidae)
Oligonychus biharensis (Acari: Tetranychidae)

The quarantine pests were qualitatively analyzed based on international principles and internal guidelines described in the PPQ Guidelines for Pathway-Initiated Pest Risk Assessments, Version 5.02 (USDA APHIS, 2002). This document examines pest biology in the context of Consequences of Introduction and Likelihood of Introduction. These elements help estimate Pest Risk Potential.

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I. Introduction

The purpose of the risk assessment is to examine pest risks associated with the importation of fresh, immature pods (fruits) of *Vigna unguiculata* (L.) Walp. (cowpea, sow-pea, asparagus-bean, pea-bean, yard-long bean, black-eyed pea, croweder-pea, southern-pea) from Hawaii into the continental United States. This risk assessment is qualitative; risk is expressed in the terms of High, Medium, and Low rather than quantitative terms, such as probabilities or frequencies. The methodology and rating criteria can be found in *Pathway-Initiated Pest Risk Assessments: Guidelines for Qualitative Assessments, Version 5.0.2* (USDA, 2000).

Regional and international plant protection organizations, North American Plant Protection Organization [NAPPO] and the International Plant Protection Convention [IPPC] administered by the Food and Agriculture Organization [FAO] of the United Nations, provide guidance for conducting risk analyses. The methods used to initiate, conduct, and report this assessment are consistent with guidelines provided by NAPPO and FAO. Our use of biological and phytosanitary terms conforms to the *Definitions and Abbreviations* (Introduction Section) in *International Standards for Phytosanitary Measures, Section 1-Import Regulations: Guidelines for Pest Risk Analysis* (IPPC, 1996).

The FAO guidelines describe three stages of pest risk analysis: Stage 1, Initiation, Stage 2, Risk Assessment, and Stage 3, Risk Management. The present document satisfies the requirements of FAO Stages 1 and 2.

Cowpeas (Fabacea: *Vigna unguiculata*) (Fig. 1) are also known as black-eyed peas, crowder peas, asparagus beans, yard longbeans, catjang, and many other common names (Weirsema and Leon, 1999). According to Weirsema and Leon (1999), there are ten subspecies:

V.u. subsp. *baoulensis* (A. Chev) Pasquet
V.u. subsp. *burundiensis* Pasquet
V.u. subsp. *cylindrica* (L.) Verdc.
V.u. subsp. *dekindtiana* (harms) Verdc.
V.u. subsp. *letouzeyi* Pasquet
V.u. subsp. *pubescens* (R. Wilczek) Pasquet
V.u. subsp. *sesquipedalis* (L.) Verdc.
V.u. subsp. *stenophylla* (Harv.) Marechal et al
V.u. subsp. *tenuis* (E. Mey.) Marechal et al
V.u. subsp. *unguiculata* Walp

The main subspecies of agricultural importance are *cylindria, sesquipedalis,* and *unguiculata* (CABI, 2004). Cowpea is native to Africa, and is one of the most ancient crops known to man. It is cultivated worldwide, primarily for its seeds, but also for its use as a vegetable, cover crop and fodder (TJAI, 2005). Worldwide production is estimated to be around 20 million acres (TJAI, 2005). Africa produces two-thirds of the total amount grown globally, with Nigeria and Niger accounting for approximately half of the world's production. Brazil produces about one-quarter of the world's total (CABI, 2004). Haiti, India, Myanmar, Sri Lanka, Australia, the United States, Bosnia and Herzegovina all have significant production (TJAI, 2005).

Green pods are harvested by hand when they are still immature and tender (12-15 days after flowering). Pod picking may continue for 6-8 weeks for yard-long bean. When grown as a pulse, harvesting is complicated by the prolonged and uneven ripening of many cultivars. The time of harvesting is critical, as mature pods shatter easily; as a result, hand-picking can be advantageous. Plants are usually pulled when most of the pods are mature. For hay, the crop is cut when most of the pods are well-developed (CABI, 2004).

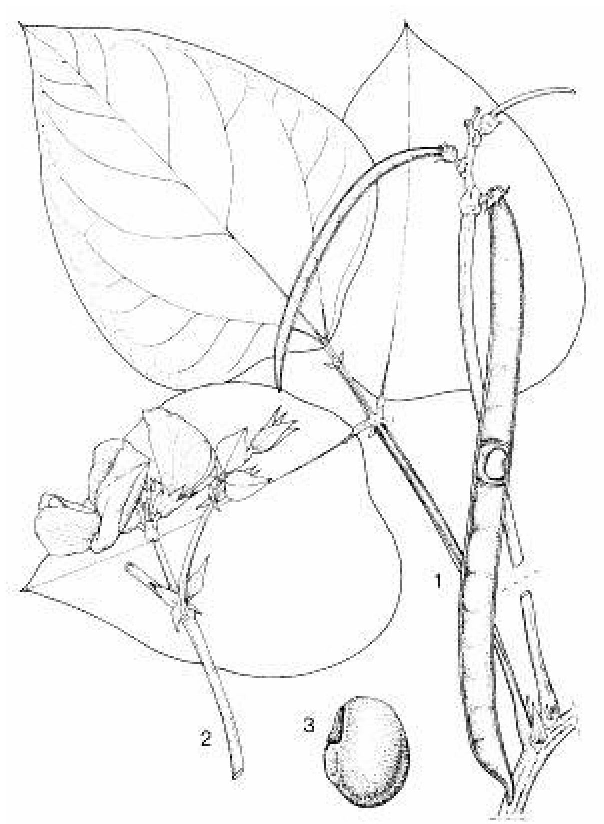

Figure 1: Cowpea, *Vigna unguiculata* (L.) Walp.
(CABI, 2004).

II. Risk Assessment

2.1 Initiating Event

This risk assessment was developed in response to a request by the Hawaii Department of Agriculture for USDA authorization to permit imports of fresh fruit pods of cowpeas into the continental United States. Entry of this commodity into the continental United States presents the risk of introduction of exotic plant pests. Title 7, Part 318, Section 13 of the United States Code of Federal Regulations (7 CFR §318.13) provides regulatory authority for the movement of fruits and vegetables from Hawaii into the continental United States.

2.2 Assessment of Weediness Potential

The results of weediness screening of yard-long-bean from Hawaii (Table 1) did not prompt a pest-initiated risk assessment.

Table 1. Process for Determining Weediness Potential of the Commodity
Commodity: Immature pods of *Vigna unguiculata* (L.) Walp. subsp. *sesquipedalis* (L.)Verdc. (yard-long-bean, long-bean, asparagus-bean) (Fabaceae) for consumption. **Phase 1**: Yard-long-beans are cultivated throughout the United States. **Phase 2**: Is the subspecies listed in: NO *Geographical Atlas of World Weeds* (Holm *et al.*, 1979). NO *World's Worst Weeds* (Holm *et al*., 1977). NO *Report of the Technical Committee to Evaluate Noxious Weeds; Exotic Weeds for Federal Noxious Weed Act* (Gunn and Ritchie, 1982). NO *Economically Important Foreign Weeds* (Reed, 1977). NO *Composite List of Weeds* (Weed Science Society of America, 1989). NO *World Weeds* (Holm, *et al.*, 1997). NO Is there any literature reference indicating weediness (*e.g., AGRICOLA, CAB, Biological Abstracts*, and *AGRIS* search on "subspecies name" combined with "weed"). **Phase 3: Conclusion**: The species has not been reported to be weedy. Seeds are available from garden centers and seed suppliers. The weediness potential of importing the commodity from Hawaii is negligible.

2.3 Previous Risk Assessments, Decision History, Current Status and Pest Interceptions

Previous Risk Assessments:

In December 2001, a risk assessment was completed on Yard-Long-Bean (*Vigna unguiculata* (L.) Walp. subsp. *sesquipedalis* (L.) Verdc.) imported as fresh immature fruit pods from Nicaragua into the continental United States by the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ), Center for Plant Heath Science and Technology (CPHST).

Decision History:

2002- Nicaragua: Yard-long-bean (*Vigna unguiculata* ssp. *sesquipedalis*): Beans permitted entry with treatment T101-k-2 or T101-k-1 (fumigation with Methyl Bromide).

1995- Honduras: Yard-long-bean, pod or shelled (*Vigna unguiculata)*: Beans without pods are permitted entry subject to inspection. Unshelled beans in fruit pods are permitted entry with treatment T101-k-2 for *M. vitrata* and *Epinotia aporema* (Walsingham) (Federal Register, 1996).

1971- Guam: Asparagus bean (*Vigna sesquipedalis):* Entry was disapproved due to pathogens *Phakopsora pachyrhizi* Syd., *Phyllosticta noackiana* Allesch., and *Septoria vignae sinensis* Saw.

1948- Mexico: Asparagus bean (*Vigna sesquipedalis):* Entry was approved subject to careful inspection for *Epinotia opposita* Hein, *Laspeyresia leguminis* Hein, and *Maruca testulalis* (Geyer).

Current Status:

Cowpea (*Vigna unguiculata*) exports from Hawaii into the continental United States are not authorized by 7 CFR §318.13. PPQ records indicate that unauthorized *Vigna* cargo has occasionally been shipped to the United States.

Pest Interceptions:

The PIN 309 database (USDA APHIS PPQ, 2005) is a searchable computer record of interceptions by APHIS inspectors maintained for internal use by the USDA (February, 2005).

Table 3. USDA Pest Interceptions on *Vigna* sp. from Hawaii (1985-2004) (PIN 309, 2005)				
Pest	**Host**	**Plant Part**	**Where Found**	**Freq.**
Aleurodicus dispersus	*Vigna sp.*	Leaf	Permit Cargo	1
Auchenorrhyncha sp.	*Vigna sp.*	Leaf	Permit Cargo	1
Lampides boeticus	*Vigna sp.*	Fruit/Pod	Baggage	1
Lampides boeticus	*Vigna sp.*	Fruit/Pod	General Cargo	1
Lampides boeticus	*Vigna sp.*	Seed	Baggage	1
Maruca vitrata	*Vigna sp.*	Fruit/Pod	Baggage	2
Thripidae, species of	*Vigna sp.*	Leaf	Permit Cargo	1
Maruca vitrata	*Vigna sp.*	Seed	Baggage	1
Maruca vitrata	*Vigna sp.*	Fruit/Pod	General Cargo	2
Aphidae, species of	*Vigna unguiculata*	Stem	General Cargo	1
Hypothenemus sp.	*Vigna unguiculata*	Seed	General Cargo	1
Lampides boeticus	*Vigna unguiculata*	Fruit/Pod	Permit Cargo	2
Lampides boeticus	*Vigna unguiculata*	Seed	Baggage	1
Maruca vitrata	*Vigna unguiculata*	Fruit/Pod	Baggage	4
Maruca vitrata	*Vigna unguiculata*	Fruit/Pod	Permit Cargo	2
Maruca vitrata	*Vigna unguiculata*	Fruit/Pod	General Cargo	4
Maruca vitrata	*Vigna unguiculata*	Fruit/Pod	Mail	1
Maruca vitrata	*Vigna unguiculata*	Seed	General Cargo	1
Maruca vitrata	*Vigna unguiculata*	Seed	Baggage	4
Maruca vitrata	*Vigna unguiculata*	Seed	Permit Cargo	2
Monolepta sp.	*Vigna unguiculata*	Fruit/Pod	General Cargo	1
Cicadellidae, sp.of	*Vigna unguiculata, ssp. sequipedalis*	Fruit/Pod	Permit Cargo	1
Maruca vitrata	*Vigna unguiculata, ssp. sequipedalis*	Fruit/Pod	Mail	1
Total Interceptions				**37**

2.4 Pest Categorization–Identification of Quarantine Pests and Quarantine Pests Likely to Follow the Pathway

Pests that are associated with cowpea and occur in the Hawaiian Islands are depicted in Table 4. This list includes information on the presence or absence of these pests in the United States, the affected plant part(s), the quarantine status of the pest with respect to the United States, an indication of the pest-host association, and pertinent references for pest distribution and biology.

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution** [1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
ARTHROPODS					
ACARI					
Tarsonemidae					
Polyphagotarsonemus latus Banks	HI, US	P/F, L, I, S	No	Y	CABI, 2004; Kessing and Mau, 1993
Tetranychidae					
Oligonychus biharensis Hirst	HI	P/F, L, I	Y	Y[4]	Chia *et al*, 1997; IDIDAS, 2004; CABI, 2004; Bishop Museum, 2002; Bolland *et al*., 1998
Tetranychus cinnabarinus (Boisduval)	HI, US (CA, TX)	L	N	N	CABI, 2003; Hill, 1994; Maes and Robleto, 1988, Bishop Museum, 2002; Jeppson *et al*, 1994.
Tetranychus desertorum Banks	HI, US	L	N	N	CABI, 2003; Schuster and Cherry, 1975; Bishop Museum, 2002; Bolland *et al*, 1998; Jeppson *et al*, 1994.
Tetranychus gloveri Banks	HI, US	L	N	N	Bolland *et al*, 1998; Jeppson *et al*, 1994.
Tetranychus ludeni Zacher	HI, US	L	N	N	Bolland *et al*, 1998; Bishop Museum, 2002; CABI, 2003; Jeppson *et al*, 1994.

[1] Distribution (specific states are listed only if distribution is limited): AL = Alabama; CA = California; FL = Florida; GA = Georgia; HI = Hawaii; LA = Louisiana; MS = Mississippi; TX = Texas; US = continental United States (widespread)

[2] Plant Parts: I = Flowers, L = Leaves, P/F = Pods (fruit), S = Stems, Sd = Seeds, R = Roots, G = Growing Points, O = Vegetative organs

[3] Brackets indicate that the species, although not fitting the definition of a quarantine pest (IPPC, 2002), is actionable (APHIS, PPQ, National Identification Services).

[4] *Oligonychus biharensis* is ranked as the 4th most important potentially invasive pest species of Tetranychoidea by the Acarological Society of America. Little information is known about the biology of this pest. Based on the behavior of other *Oligonychus*, it may follow the pathway. *Oligonychus* spider mites generally feed on leaves, when populations are large; however, some *Oligonychus* mites are found on fruit. Species of *Oligonychus* have been intercepted on citrus fruit at U.S. ports (USDA APHIS PPQ, 2005) and members of the genus are associated with date fruit. The calyx provides excellent hiding places for mites. Until further information can be obtained about this species and its behavior on *Vigna,* we assume that it may follow the pathway.

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution [1]**	**Plant Part Affected [2]**	**Quarantine Pest [3]**	**Likely to Follow Pathway**	**References**
Tetranychus neocaledonicus Andre	HI, US	L	N	N	Bolland *et al*, 1998; Bishop Museum, 2002; Jeppson *et al*, 1994.
Tetranychus urticae Koch	HI, US	L	N	N	Bolland *et al*, 1998; Bishop Museum, 2002; Jeppson *et al*, 1994.
INSECTS					
COLEOPTERA					
Anobiidae					
Lasioderma serricorne Fabricius	HI, US	L, R, Sd	N	Y	CABI, 2003; Bishop Museum, 2002; Arnett *et al*, 2002; Hill, 1994
Apionidae					
Cylas formicarius Fabricius	HI, US	L, S, R	N	N	CABI, 2003, Bishop Museum, 2002; Arnett *et al*, 2002; Hill, 1994
Bruchidae					
Anthonomus eugenii Cano	HI, US	P/F, I, L	N	Y	CABI, 2004: Kessing and Mau, 1993
Acanthoscelides obtectus (Say)	HI, US	Sd	N	Y	CABI, 2003; Metcalf and Metcalf, 1993; Bishop Museum, 2002; Hill, 1994; Jackai and Daoust, 1986
Callosobruchus chinensis (Linnaeus)	HI, US	Sd	N	Y	CABI, 2003; Bishop Museum, 2002; Capinera, 2001
Callosobruchus maculatus (Fabricius)	HI, US	Sd	N	Y	CABI, 2003; Metcalf and Metcalf, 1993; Bishop Museum, 2002; Arnett et al, 2002; Hill, 1994; Jackai and Daoust, 1986; Capinera, 2001
Zabrotes subfasciatus (Boheman) (Coleoptera: Bruchidae)	HI, US	Sd	N	Y	CABI, 2003; Bishop Museum, 2002; Arnett et al, 2002;

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution** [1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
Chrysomelidae					
Octotoma scabripennis	HI	L, S	Y	N[5]	CABI, 2003; Bishop Museum 2002; Davis, 1972; Baars & Heystek, 2003
Curculionidae					
Pantomorus cervinus (Boheman) = Asynonychus godmanni	HI, US	L, R, P/F	N	Y	CABI, 2003; Jackai and Daoust, 1986
Sitophilus oryzae (Linnaeus)	HI, US	Sd	N	Y	CABI, 2003; Bishop Museum, 2002; Hill, 1994; Koehler, P. G.
Elateridae					
Conoderus amplicollis (Gyllenhal)	HI, US	P/F, L, S, I, Sd, I	N	Y	CABI, 2004; Stone and Wilcox, 1979
Nitidulidae					
Carpophilus dimidiatu (F.)	HI, US	P/F, L, Sd	N	Y	CABI, 2003; Bishop Museum, 2002; Hill, 1994
Carpophilus hemipterus (L.)	HI, US (NM, CA)	P/F, Sd	N	Y	CABI, 2003; Bishop Museum, 2002; Hill, 1994;
Carpophilus humeralis (Fabricius)	HI, US	S, P/F	N	Y	CABI, 2003; Bishop Museum, 2002
DIPTERA					
Agromyzidae					
Liriomyza sativae (Blanchard)	HI, US	L, S, Sd, R	N	Y	CABI, 2003; Bishop Museum 2002; Hill, 1994; Spencer and Steyskal, 1986
Liriomyza trifolii Burgess (Diptera: Agromyzidae)	HI, US	L, S, Sd, R	N	Y	CABI, 2003; Maes and Robleto, 1988; Bishop Museum, 2002; Hill, 1994; Jackai and Daoust, 1986; Spencer and Steyskal, 1986

[5] *Octotoma scabripennis* (Coleoptera: Chrosomelidae) was not selected for further analysis because it is primarily a leaf and and stem feeder, and is not expected to be associated with the fruit. *O. scabripennis* is a biological control agent of the weed *Lantana camara* (Cilliers and Neser, 1991).

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution**[1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
Ophiomyia phaseoli Tryon	HI	L, S, R . P/F	Y	N[6]	CABI, 2003; Bishop Museum, 2002; Hill, 1994; Jackai and Daoust, 1986; Hardy and Delfinado, 1980; Spencer and Steyskal, 1986; PKNTO
Tephritidae					
Bactrocera cucurbitae Coquillett	HI	L, S, R, I, P/F, Sd	Y	Y	CABI, 2003; Bishop Museum, 2002; Mathew *et al.*, 1999; Allwood *et al*, 1998; White and Elson-Harris, 1994; SPC, 2002; USDA APHIS PPQ, 2005; Capinera, 2002
HEMIPTERA					
Aleyrodidae					
Aleurodicus dispersus Russell	HI, FL	L, P/F	Y[7]	Y[8]	Anonymous, 2004; Martin, Kessing & Mau, 1993
Bemisia argentifolii Bellows, Perring, Gill & Hendrick	HI, US	L	N	N	CABI, 2004; Kessing and Mau, 1993
Bemisia tabaci (Gennadius)	HI, US	L	N	N	CABI, 2004; Kessing and Mau, 1993
Trialeurodes vaporariorum Westwood	HI, FL	L	N	N	CABI, 2004; Kessing and Mau, 1993

[6] *Ophiomyia phaseoli* (Diptera: Agromyzidae) is one of the most important pests of legumes worldwide. Should this species be introduced into the continental United States, there would likely be serious consequences for bean production in the southeastern United States; however, it is not likely that this species would follow the pathway. It prefers to tunnel and feed in leaves and stems of young plants,and is highly unlikely to be assocaited with marketable pods (CABI, 2004). *Ophiomyia phaseoli* eggs are deposited in leaves and larvae tunnel through the petiole to the stem. While there is an extremely low probability of tunneling to young pods, the damage would be apparent in mature pods (Liquido, *pers. comm.*).

[7] This pest has a limited distribution in the United States, but is considered an actionable pest by PPQ.

[8] *Aleurodicus dispersus* is a whitefly that mainly feeds on leaves; however, it may be associated with fruit and has been intercepted on the fruit of several different hosts at U.S. ports (USDA APHIS PPQ, 2005).

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution**[1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
Miridae					
Lygus elisus Van Duzee	HI, US	I, Sd	N	Y	Jackai and Daoust, 1986; Henry and Froeschner, 1998
Pentatomidae					
Nezara viridula (Linnaeus) (Hemiptera: Pentatomidae)	HI, US	L, S, G, I, P/F, Sd	N	Y	CABI, 2003; Maes and Robleto, 1988; Bishop Museum, 2002; HDOA, 2004; Hill, 1994; Jackai and Daoust, 1986
HOMOPTERA					
Aphididae					
Acyrthosiphon pisum Harris	HI, US	L, G, I	N	N	CABI, 2003; Bishop Museum, 2002; Hill, 1994
Aphis craccivora Koch	HI, US	L, S, G	N	N	CABI, 2003 Blackman and Eastop, 2000; CABI, 2003; IIE, 1983; Bishop Museum, 2002; Hill, 1994; Jackai and Daoust, 1986
Aphis fabae Scopoli	HI, US	L, S, I	N	N	CABI, 2004
Aphis gossypii Glover	HI, US	L, S, I	N	N	CABI, 2004
Aphis spiraecola Patch	HI, US	L, S, I	N	N	CABI, 2004
Macrosiphum euphorbiae (Thomas)	HI, US	L, S, I,	N	N	CABI, 2003; Bishop Museum, 2002; Hill, 1994
Myzus persicae (Sulzer)	HI, US	I, L, S, G	N	N	CABI, 2003; Maes and Robleto, 1988; Bishop Museum, 2002; Hill, 1994
Cicadellidae					
Empoasca solana DeLong	HI, US?	L	N	N	Kessing and Mau, 1993
Coccidae					
Coccus longulus (Douglas)	HI, US	S, L	N	N	Scalenet, 2005; Anon., 2004
Saissetia neglecta De Lotto[4]	HI, US	S, L, P/F	N	Y	Scalenet, 2005; Anon, 2004

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution** [1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
Diaspididae					
Aspidiotus destructor Signoret	HI, US	P/F, L, S	N	Y	CABI, 2003; Dekle, 1965; Bishop Museum, 2002; Scalenet, 2004
Pseudococcidae					
Dysmicoccus brevipes (Cockerell)	HI, US	L, S, R, P/F	N	Y	Scalenet, 2004; Bishop Musuem, 2002; Hill, 1994
Dysmicoccus neobrevipes Beardsley	HI (PR, VI, AS, GU)	L, S, R, P/F	Y[9]	Y	Scalenet, 2004; Bishop Museum, 2002; CABI, 2004; USDA APHIS PPQ, 2005
Ferrisia virgata (Cockerell)	HI, US	L, P/F, S,	N	Y	Arnett, 1985; Ben-Dov, 1994; CABI, 2003; IIE, 1966; Scalenet, 2001; Bishop Museum, 2002
Maconellicoccus hirsutus (Green)	HI, US*	L, S, P/F, R, I	Y[10]	Y	Scalenet, 2004; Bishop Museum, 2002; Hill, 1994; Hoy *et al*, 2003; Persad, 1995; USDA APHIS PPQ, 2005*
Phenacoccus solani Ferris[4]	HI, US	L, P/F, S	N	Y	Scalenet, 2005
LEPIDOPTERA					
Cosmopterigidae					
Pyroderces rileyi (Walsingham)	HI, US	P/F, Sd	N	Y	CABI, 2004; Robinson *et al.*, 2003
Lycaenidae					
Lampides boeticus Linnaeus	HI	I, P/F, Sd	Y	Y	CABI, 2003; Bishop Museum, 2002; Zhang 1994; Hill, 1994; Zimmerman, 1958; USDA APHIS PPQ, 2005
Noctuidae					
Achaea janata L.	HI	L, S, P/F	Y	N[11]	Robinson *et al*, 2003; Hill, 1994; Bishop Museum, 2002; CABI, 2004; USDA APHIS PPQ, 2005*

9 This pest has a limited distribution in the United States, but is considered an actionable pest by PPQ.
10 This pest has a limited distribution in the United States, but is considered an actionable pest by PPQ.
11 This pest is an external feeder. Only adults, which are highly mobile, are known to attack fruit. The pest is not likely to remain on the commodity through harvest and processing.

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution [1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway**	**References**
Agrotis ipsilon (Hufnagel)	HI, US	L, S, P/F	N	Y	CABI, 2003; Bishop Museum, 2002; Zhang 1994; Hill, 1994; Jackai and Daoust, 1986
Argyrogramma verruca Fabricius	HI, US	L, S, P/F	N	Y	Poole, 1989; CABI, 2004; Zhang, 1994
Helicoverpa zea (Boddie)	HI, US	I, L, S P/F, Sd	N	Y	CABI, 2003; Bishop Museum, 2002; Zhang 1994; Jackai and Daoust, 1986
Heliothis virescens (Fabricius)	HI, US	P/F, I, L, Sd	N	Y	CABI, 2004; Robinson *et al.*, 2003
Penicillaria jocosatrix (Guenée)	HI, US?	L, I, S, P/F	Y	N[12]	CABI, 2004; Nafus, 1991; Robinson *et al.*, 2003
Stictoptera cuculliоides (Guenee)	HI	L, S	Y	N[13]	Zhang, 1994; Bishop Museum, 2002; Khatua, 1997
Spodoptera exempta Walker	HI, US	L, S	Y	N	CABI, 2004; Robinson *et al.*, 2003
Spodoptera exigua (Hubner)	HI, US	L, I, G, P/F,	N	Y	CABI, 2003; Maes and Robleto, 1988; Bishop Museum, 2002; Zhang, 1994; Hill, 1994; Pogue, 2003
Spodoptera litura (Fabricius)	HI	L, I, G, P/F,	Y	Y	CABI, 2003; Bishop Museum, 2002; Zhang, 1994; Hill, 1994; Pogue, 2003; USDA APHIS PPQ, 2005
Spodoptera mauritia subsp. *acronyctoides* Guenée	HI	L, I, G,	Y	N[14]	CABI, 2003; Bishop Museum, 2002; Zhang, 1994; Hill, 1994; Pogue, 2003; USDA APHIS PPQ, 2005
Trichoplusia ni (Hübner)	HI, US	L, I, G, P/F,	N	Y	CABI, 2003; Bishop Museum, 2002; Zhang, 1994; Hill, 1994
Pyralidae					

[12] This species mainly feeds on flowers and leaves and is not likely to be in the pathway. Larvae have been known to occasionally attack the fruit of mangos.
[13] *Stricotptera cuculliоides* (Lepidoptera: Noctuidae) is a defoliator that feeds primarily on the leaves of plants in the Clusiaceae family (Zhang, 1994). Although there is some evidence that S. cuculliоides can feed on Vigna spp., it would not be likely to follow the pathway.
[14] *Spodoptera mauritia* is a lawn army worm that primarily feeds on leaves. There is no evidence that this species is associated with fruits or pods, although other *Spodoptera* spp. may occasionally bore into the fruit or pod.

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution [1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway**	**References**
Cadra cautella Walker	HI, US?	P/F, Sd, R	N	Y	CABI, 2004; Kessing and Mau, 1993
Elasmopalpus lignosellus (Zeller)	HI, US	L, S, R. G	N	N	CABI, 2003; Zhang, 1994; Robinson *et al*, 2003; Hill, 1994; Jackai and Daoust, 1986
Maruca vitrata Fabricius[9] = *Maruca testulalis* Geyer	HI	I, L, P/F	Y	Y	APHIS, 2000; Julius, *et al*., 1992; CABI, 2003; Federal Register, 1996; IIE, 1996; Ke, *et al.*, 1985; Maes and Robleto, 1988; Oakley, 1953; Zhang 1994; Bishop Museum, 2002; Robinson *et al*, 2003; Hill, 1994; Jackai and Daoust, 1986; USDA APHIS PPQ, 2005
Spoladea recurvalis (Fabricius)	HI, US	S, I, L, R	N	N	CABI, 2004; Robinson *et al.*, 2003
Tortricidiae					
Cryptophlebia ombrodelta (Lower)	HI	P/F, Sd	Y	Y	CABI, 2004; Robinson *et al.*, 2003
Platynota stultana Walsingham	HI, US	L, I, P/F	N	Y	CABI, 2003; Bishop Museum, 2002
THYSANOPTERA					
Thripidae					
Frankliniella fusca (Hinds)	HI, US	L, S, G, I, P/F,	N	Y	CABI, 2003: Bishop Museum, 2002; Hill, 1994; Capinera, 2001
Frankliniella schultzei (Trybom)	HI, (US: reportable)	L, G, I, P/F,	[Y]	Y	CABI, 2003; Bishop Museum, 2002; Hill, 1994; USDA APHIS PPQ, 2005
Thrips palmi Karny	HI, US (FL)	L, G, P/F	[Y]	Y	CABI, 2003; Bishop Museum, 2002; Nakahara, 1994; Hill, 1994; Jackai and Daoust, 1986; USDA APHIS PPQ, 2005
NEMATODES					
DORYLAIMIDA					
Longidoridae					

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution** [1]	**Plant Part Affected** [2]	**Quarantine Pest** [3]	**Likely to Follow Pathway**	**References**
Xiphinema americanum Cobb	HI, US	R	N	N	CABI, 2003
TYLENCHIDA					
Anguinidae					
Ditylenchus destructor Thorne	HI, US*	S, R	[Y][15]	N	CABI, 2003; USDA APHIS PPQ, 2005
Belonolaimidae					
Belonolaimus longicaudatus Rau (Tylenchida:)	HI, US	R	N	N	CABI, 2003; Minton and Baujard, 1990
Hoplolaimidae					
Helicotylenchus dihystera (Cobb) Sher.	HI, US	R	N	N	CABI, 2003; Whitehead, 1998
Rotylenchulus reniformis Linford & Oliveira	HI*, US	R	N	N	CABI, 2004
Helicotylenchus multicinctus (Cobb) Golden	HI, US*	R	[Y][14]	N	CABI, 2003; Whitehead, 1998; USDA APHIS PPQ, 2005
Scutellonema brachyurus Steiner (1938) Andrássy	HI, US	R	N	N	CABI, 2003
Meloidogynidae					
Meloidogyne arenaria (Neal) Chitwood	HI, US	R	N	N	CABI, 2003; Sikora and Greco, 1990; Whitehead, 1998
Pratylenchidae					
Pratylenchus brachyurus (Godfrey) Filipjev & Schuurmans Steckhoven	HI, US	R, S	N	Y	ARS, 1960; CABI, 2003; Minton and Baujard, 1990; Whitehead, 1998
FUNGI					
Alternaria alternata (Fr.:Fr.) Keissl. (syn. *A. tenius*)	HI, US	L, F, S, Sd	N	Y	Farr *et al*., 2005

[15] Most nematodes are primarily root pests that live solely underground—this is the case of *Ditylenghus destructor* and *Helicotylenchus multicinctus*. These pests would not be expected to be associated with the pods/fruit of cowpea, and are not likely to follow the pathway.

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution** [1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
Ascochyta boltshauseri Sacc. (syn. *Stagonosporopsis hortensis* (Sacc. & Malbr.) Petr.)	HI, US	S, L, P/F	N	Y	Farr *et al*., 2005
Ascochyta pisi Lib. (syn. *A. pisicola*)	HI, US	L, P/F, S, Sd	N	Y	Farr *et al*., 2005
Aspergillus flavus Link (Anamorphic fungi)	HI, US	L, S, P/F, Sd	N	Y	CABI, 2003; Farr *et al*, 2005;
Aspergillus niger Tiegh.	HI, US	L, S, P/F, Sd	N	Y	Farr *et al*., 2005
Aspergillus parasiticus Speare	HI, US	Sd?	N	Y	Farr *et al*., 2005
Botryodiplodia theobromae Pat. (syn. *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl.)	HI, US	P/F, L, S, R	N	Y	Farr *et al*., 2005
Botrytis cinerea Pers.:Fr.	HI, US	P/F, L, S, Sd, R, I	N	Y	Farr *et al*., 2005
Cercospora apii Fresen.	HI, US	L	N	N	Farr *et al*., 2005
Cercospora canescens Ellis & G. Martin [=*Cercospora vignicaulis* Tehon]	HI, US	L	N	N	Thurston, 1998; Farr *et al*, 2005;
Pseudocercospora cruenta (Sacc.) Deighton [= *Cercospora cruenta* Sacc.; *Cercospora phaseoli* Dearn. & Barth; *Cercospora phaseolorum* Cooke]	HI, US	L	N	N	Thurston, 1998; Farr *et al*, 2005; Raabe, 1981
Cercospora nicotianae Ellis & Everh. (syn. *C. raciborskii* Sacc. & Syd.)	HI, US	L, S	N	N	Farr *et al*., 2005
Choanephora cucurbitarum (Berk. & Ravenel) Thaxt. (syn. *C. amaricana* A. Mölle)	HI, US	P/F, I, S, R	N	Y	Farr *et al*., 2005
Cicinobolus cesatii de Bary	HI, US	L	N	N	Farr *et al*., 2005
Cladosporium cladosporioides (Fresen.) G.A. De Vries	HI, US	L, P/F, Sd	N	Y	

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Pest	**Geographic Distribution** [1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
Cochliobolus heterostrophus (Drechs) Dresch. (Loculoasco- mycetes: Dothidales) [= *Ophiobolus heterostrophus* Drechs; *Bipolaris maydis* (Nisikado & Miyake) Shoemaker - Anamorph]	HI, US	L, S, I, Sd	N	N	CABI, 2003; CMI, 1971a; CMI, 1981, Raabe, 1981
Cochliobolus lunatus Nelson & Haasis- Pleosporales [=*Pseudocochliobolus lunatus* (R.R. Nelson & Haasis) Tsuda, Ueyama & Nishihara; *Curvularia lunata* (Wakk.) Boedijn – Anamorph] (Loculoasco- mycetes: Dothidales)	HI, US	L, S, I	N	N	CABI, 2003; CMI, 1975; Farr *et al*, 2005;
Colletotrichum lindemuthianum (Sacc. & Magnus) Lams.-Scrib. (Deuteromycotina: Coleomycetes) [Teleomorph *Glomerella lindemuthiana* = *G. cingulata*]	HI, US,	L, P/F, S, Sd	N	Y	Allen, *et al.*, 1998; ARS,1960; CABI, 2003; Thurston, 1998; CMI 1971b; CMI 1978a; Wellman, 1977; Farr *et al*, 2005; Valenzuela and Smith, 2002
Colletotrichum truncatum (Schwein.) Andrus & W.D. Moore, 1934 [=*Colletotrichum dematium f. truncatum* (Schwein.) Arx; *Vermicularia polytricha* Cooke; *Colletotrichum truncatum f. truncatum* (Schwein.) Andrus & W.D. Moore	HI, US	L, S, P/F, I	N	Y	CABI, 2003; Farr, *et al*, 1995; Farr *et al*, 2005;

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution** [1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
Corynespora cassiicola (Berk. & M.A. Curtis) C.T. Wei (syn. *C. vignicola* E. Kawam)	HI, US	P/F, L, S, I, R	N	Y	Farr *et al*., 2005
Curvularia senegalensis (Speg.) Subram.	HI, LA	L	N	N	Farr *et al*., 2005
Cylindrocladium clavatum Hodges & L.C. May	HI, FL	L, R	N	N	Farr *et al*., 2005
Diaporthe phaseolorum (Cooke & Ellis) Sacc.	HI, US	P/F, S,	N	Y	Farr *et al*., 2005
Erysiphe polygoni DC	HI, US	F/P, I, L, S, Sd	N	Y	Valenzuela and Smith, 2002; Farr *et al*, 2005
Fusarium graminearum Schwabe (anamorph) *Gibberella zeae* (Schwein.:Fr.) Petch (teleomorph)	HI, US	Sd, L, R	N	Y	Farr *et al*., 2005
Fusarium oxysporum vr. *tracheiphilum* (E.F.Sm.) Snyder & H.N. Hansen (Pyrenomycetes: Hypocreales)	HI, US	F/P, L, R. Sd	N	Y	Valenzuela and Smith, 2002; CABI, 2004; Farr *et al*, 2005
Fusarium oxysporum f. sp. vasinfectum (Atk.) W.C. Snyder & H.N. Hans.	HI, US	S, R	N	N	Farr *et al*., 2005
Fusarium solani (Mart.) Sacc. (anamorph) *Nectria haematococca* (Wollenw.) Gerlach (teleomorph)	HI, US	P/F, L, S	N	Y	Farr *et al*., 2005
Fusarium subglutinans (Wollenw. & Reinking) P.E. Nelson, Toussoun & Marasas (anamorph) *Gibberella subglutinans* (E. Edwards) P.E. Nelson, Toussoun & Marasas (teleomorph)	HI, US	L	N	N	Farr *et al*., 2005

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution [1]**	**Plant Part Affected[2]**	**Quarantine Pest[3]**	**Likely to Follow Pathway**	**References**
Gibberella fujikuroi (Sawada) Ito in Ito & [=*Gibberella moniliforme* (J. Sheld.) Wineland; *Lisea fujikuroi* Sawada*;* *Fusarium moniliforme* J. Sheld. - Anamorph] Kimura (Pyrenomycetes: Hypocreales)	HI, US	L, S, R, P/F, Sd	N	Y	CABI, 2003; CMI 1964a; CMI 1977; Farr *et al*, 2005
Glomerella cingulata (Stonem.) Spauld. & Schrenk (Ascomycetes) (teleomorph) *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. (anamorph)	HI, US	P/F, I, L, S, Sd	N	Y	CABI, 2003; Wellmann, 1977
Leveillula taurica (Lév.) G. Arnaud (syn. *Erysiphe taurica* Lév.)	HI, US	L, S, I	N	N	Farr *et al*., 2005
Macrophomina phaseolina (Tassi) Goidanich =*Sclerotium bataticola* (Coelomycetes)	HI, US	P/F, I, L, R, S, Sd	N	Y	CABI, 2004; Farr *et al*, 2005; Wellmann, 1977; Valenzuela and Smith, 2002
Mycosphaerella pinodes (Berk. & Bloxam) Vestergr. (teleomorph) *Ascochyta pinodes* L.K. Jones (anamorph)	HI, US	L, S, R, P/F	N	Y	Farr *et al*., 2005
Penicillium citrinum Thom (syn. *Penicillium steckii)* Zaleski	HI, US	L	N	N	Farr *et al*., 2005
Penicillium glabrum (Wehmer) Westling	HI, US	L	N	N	Farr *et al*., 2005
Periconia byssoides Pers.	HI, US	L, P/F, S	N	Y	Farr *et al*., 2005
Peronospora trifoliorum de Bary	HI, US	L, S, I	N	N	Farr *et al*., 2005

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution [1]**	**Plant Part Affected [2]**	**Quarantine Pest [3]**	**Likely to Follow Pathway**	**References**
Phaeoisariopsis griseola (Sacc.) Ferraris	HI, US	L, S, P/F, Sd	N	Y	CABI, 2003; Farr *et al*, 2005
Phakopsora pachyrhizi Syd. & P. Syd.	HI, US	L, S, P/F	Y	N[16]	APHIS, 2004; CABI, 2003; USDA APHIS PPQ, 2005; Farr *et al*., 2005
Phoma exigua var. exigua Desm	HI, US	L, S, R, P/F	N	Y	Farr *et al*., 2005
Phyllosticta phaseolina Sacc. (Deuteromycotina: Coelomycetes)	HI, US	L	N	N	Farr, *et al*, 1995; Farr *et al*, 2005
Phytophthora cactorum (Lebert & Cohn) J. Schröt.	HI, US	P/F, S, L, R	N	Y	Farr *et al*., 2005
Phytophthora cryptogea Pethybr. & Laff.	HI, US	P/F, S, L, R, I	N	Y	Farr *et al*., 2005
Phytophthora drechsleri Tucker	HI, US	P/F, S, R	N	Y	Farr *et al*., 2005
Phytophthora nicotianae Breda de Haan (syn. *Phytophthora parasitica var. nicotianae* (Breda de Haan; *Phytophthora parasitica* Tucker)	HI, US	P/F, L, S, Sd, R	N	Y	Farr *et al*., 2005
Pythium aphani-dermatum (Edson) Fitzp. (Oomycetes: Peronosporales)	HI, US	R, S	N	N	Allen, *et al.*, 1998; CABI, 2003; CMI, 1964b; CMI, 1978b; Thurston, 1998
Pythium debaryanum Auct. Non R. Hesse (Oomycetes)	HI, US	R, S	N	N	Farr, *et al*, 1995; Farr *et al*, 2005
Pythium hydnosporum (Mont.) J. Schrot (Oomycetes)	HI, US	R, S	N	N	Farr, *et al*, 1995
Pythium splendens H. Braun (Oomycetes)	HI, US	R, S	N	N	Farr, *et al*, 1995; Farr *et al*, 2005

[16] *Phakospora pachyrhizi* has recently been introduced in many areas in the continental United States, and is considered non-quarantine pest.

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)

Pest	Geographic Distribution [1]	Plant Part Affected [2]	Quarantine Pest [3]	Likely to Follow Pathway	References
Pythium ultimum Trow	HI, US	P/F, Sd, L, R, S	N	Y	Farr *et al.*, 2005
Pythium vexans de Bary	HI, US	R	N	N	Farr *et al.*, 2005
Rhizoctonia solani Kuhn. (Deuteromycotina: Coelomycetes)	HI, US	R, S	N	N	Farr, *et al*, 1995; Farr *et al*, 2005
Rhizopus stolonifer (Ehrenb.:Fr.) Vuill.(syn. *Rhizopus nigricans* Ehrenb.)	HI, US	P/F, Sd,	N	Y	Farr *et al.*, 2005
Sclerotium rolfsi[4] (anamorph) *Athelia rolfsii* (Curzi) Tu & Kimbr. (syn. *Corticium rolfsii* Curzi) (teleomorph)	HI, US	L	N	N	Farr *et al.*, 2005
Stemphylium solani Weber	HI, US	L	N	N	Farr *et al.*, 2005
Trichothecium roseum Link (syn. *Cephalothecium roseum*)	HI, US	P/F	N	Y	Farr *et al.*, 2005
Thanatephorus cucumeris (A. B. Frank) Donk [=*Pellicularia filamentosa* (Pat.) D. P. Rogers; anamorph *Rhizoctonia solani* Kuhn] (Basidiomycetes: Tulasnellales)	HI, US	L, S, R, I, P/F, Sd, G	N	Y	Allen, *et al.*, 1998; CABI, 2003; Thurston, 1998;
Uromyces appendiculatus (Pers.:Pers) Unger (Basidiomycetes: Uredinales)	HI, US	L, S, P/F	N	Y	Allen, *et al.*, 1998; ARS, 1960; CABI, 2003; CMI, 1965; Farr, *et al*, 1995; Thurston, 1998;
Uromyces vignae Barclay (Basidiomycotina: Uredinales)	HI, US	L, S, P/F	N	Y	Farr, *et al*, 1995
Uromyces phaseoli (Pers.) G. Winter	HI, US	L, P/F	N	N	Farr *et al.*, 2005; On Vigna catjang
Verticillium albo-atrum Reinke & Berthier	HI, US	P/F, L, S, Sd, R	N	Y	CABI, 2005; Farr *et al.*, 2005

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution** [1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
BACTERIA					
Pseudomonas savastanoi pv. *phaseolicola* (Burkholder) Gardan, *et al.* *[=Pseudomonas phaseolicola* (Burkholder) Dowson, *Pseudomonas syringae* pv. *phaseolicola* (Burkholder) Young *et al.*] (Pseudomonadales: Pseudomondaceae)	HI, US	L, S, G, P/F, Sd	N	Y	ARS, 1960; CABI, 2003; CMI, 1973; Hall 1991; Wellmann, 1977;
Xanthomonas axonopodis pv. *phaseoli* (Smith) Vauterin [=*X. campestris* pv. *phaseoli* (Smith) Dye, *X. phaseoli* (ex Smith) Gabriel] (Xanthomonadales: Xanthomonadaceae)	HI, US	L, P/F	N	Y	CABI, 2003; CMI, 1971c; Hall, 1991
VIRUSES					
Abutilon mosaic virus	HI, US	L	N	N	CABI, 2003; Lundsgaard, 2005
Beet curly top virus (Geminiviridae: Curtovirus)	HI, US	L, S, R, G, I, P/F	N	Y	CABI, 2003
Cucumber mosaic virus (Bromoviridae: Cucmovirus)	HI, US,	L, P/F	N	Y	Allen, *et al.*, 1998; Brunt, *et al.*, 1997; CABI, 2003; Gillaspie, Jr., 1998; PVO, 2004; Wellmann, 1977
Peanut mottle virus (Potyviridae: Potyvirus)	HI, US	L, S, P/F, R	N	Y	Brunt, *et al.*,1997; CABI, 2003; Hall, 1991
Tomato spotted wilt virus	HI, US	L, P/F, S, R	N	Y	CABI, 2003; Wellmann, 1977;
Alfalfa mosaic virus	HI, US	L, P/F	N	Y	PVO, 2004
Melon necrotic spot carmovirus	HI, US	L, S	N	Y	PVO, 2004

Table 4. Pests in Hawaii Associated with Cowpea (*Vigna unguiculata*)					
Pest	**Geographic Distribution**[1]	**Plant Part Affected**[2]	**Quarantine Pest**[3]	**Likely to Follow Pathway**	**References**
Ribgrass mosaic tobamovirus	HI, US	L	N	N	PVO 2004

Quarantine Pests Not Selected for Further Analysis
Quarantine pests that would reasonably be expected to follow the pathway, *i.e.*, be included in commercial shipments of cowpeas (*Vigna unguiculata*), were analyzed in detail (Step 5-7) (USDA APHIS, 2000). Other actionable plant pests not chosen for further scrutiny may be potentially detrimental to the U.S. agricultural production systems; however, there were a variety of reasons for not subjecting them to further analysis. For example, they may have been associated mainly with plant parts other than the commodity; they may have been associated with the commodity, but it was not considered reasonable to expect these pests to remain with the commodity during processing; or they have been intercepted as biological contaminants of these commodities during inspection by Plant Protection and Quarantine Officers, but would not be expected to be present with every shipment.

Quarantine Pests Selected for Further Analysis
The following quarantine pests from Hawaii listed below were selected for further analysis:

Aleurodicus dispersus (Hemiptera: Aleyrodidae)
Bactrocera cucurbitae (Diptera: Tephritidae)
Cryptophlebia ombrodelta (Lepidoptera: Tortricidae)
Dysmicoccus neobrevipes (Homoptera: Psudococcidae)
Frankliniella schultzei (Thysanoptera: Thripidae)
Lampides boeticus (Lepidoptera: Lycaenidae)
Maruca vitrata (Lepidoptera: Pyralidae)
Maconellicoccus hirsutus (Homoptera: Psudococcidae)
Oligonychus biharensis (Acari: Tetranychidae)
Spodoptera litura (Lepidoptera: Noctuidae)
Thrips palmi (Thysanoptera: Thripidae)

2.5 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). (The criteria used to determine each rating is included in Appendix A.) A Cumulative Risk Rating is then calculated by summing all Risk Element values.

The values determined for the Consequences of Introduction for each quarantine pest related to Hawaiian cowpeas are summarized in Table 5.

Consequences of Introduction: *Aleurodicus dispersus* Russell (Hemiptera: Aleyrodidae)	Risk Value
Risk Element #1: Climate – Host Interaction *Aleurodicus dispersus* is native to tropical and subtropical Central and South America, Caribbean, Africa, Asia, and Oceania (Akinlosotu *et al*., 1993). Its distribution corresponds to U.S. Plant Hardiness Zones 8-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS 2002).	Medium (2)
Risk Element #2: Host Range Spiralling whitefly, *A. dispersus*, is a highly polyphagous species. Primary host species include **Arecaceae** (*Cocos nucifera*), **Rutaceae** (*Citrus* spp.), **Papilionoideae** (*Glycine max*), **Euphorbiaceae** (*Manihot esculenta*), **Musaceae** (*Musa x paradisiacal*), **Lauraceae** (*Persea Americana*), **Rosaceae** (*Prunus* spp.), and **Myrtaceae** (*Psidium guajava*) (CABI, 2003). Other host species include **Moraceae** (*Artocarpus* spp., *Ficus* spp., *Morus* spp.), **Fabaceae** (*Acacia* spp., *Arachis hypogaea*, *Pongamia pinnata*, *Bauhinia* spp., *Cassia* spp., *Phaseolus* spp., *Vigna* spp.), **Nyctaginaceae** (*Bougainvillea* spp.), **Asteraceae** (*Chrysanthemum* spp., *Dahlia pinnata*, *Lactuca sativa*), **Lauraceae** (*Cinnamomum camphora*), **Cucurbitaceae** (*Cucumis melo*, *Luffa aegyptiaca*, *Cucumis* spp.), **Lamiaceae** (*Coleus* spp., *Salvia* spp.), **Euphorbiaceae** (*Euphorbia pulcherrima*, *Acalypha* spp., *Euphorbia* spp., *Ricinus communis*), **Myrtaceae** (*Eugenia* spp.), **Araliaceae** (*Hedera* spp.), **Oleaceae** (*Jasminum* spp., *Osmanthus fragrans*), **Convolvulaceae** (*Ipomoea batatas*, *Ipomoea* spp.), **Araceae** (*Monstera deliciosa*, *Colocasia esculenta*), **Ericaceae** (*Rhododendron* spp.), **Brassicaceae** (*Rorippa indica*), **Anacardiaceae** (*Schinus terebinthifolius*, *Mangifera indica*), **Solanaceae** (*Solanum melongena*, *Cestrum* spp., *Capsicum* spp., *Lycopersicon esculentum*, *Physalis* spp., *Solanum* spp.), **Poaceae** (*Sorghum bicolor*), **Strelitziaceae** (*Strelitzia* spp.), Zingiberaceae (*Zingiber zerumbet*), **Agavaceae** (*Agave americana*), **Amaranthaceae** (*Amaranthus* spp.), **Annonaceae** (*Annona squamosa*), **Arecaceae** (*Areca catechu*, *Chrysalidocarpus lutescens*), **Begoniaceae** (*Begonia* spp.), **Ulmaceae** (*Celtis* spp.), **Caricaceae** (*Carica papaya*), **Cannaceae** (*Cannas* pp.), **Rubiaceae** (*Coffea* spp.), **Malvaceae** (*Hibiscus* spp.), **Proteaceae** (*Macadamia* spp.), **Sapotaceae** (*Manilkara zapota*), **Musaceae** (*Musa* spp.), **Apocynaceae** (*Plumeria* spp.), **Rosaceae** (*Rosa* spp., *Rubus* spp.), and **Combretaceae** (*Terminalia catappa*) (CABI, 2003; Martin Kessing & Mau, 1993; EPPO, 2004).	High (3)
Risk Element #3: Dispersal Potential Females begin to lay eggs within a day of emergence; she will continue to lay eggs throughout her lifetime (Martin Kessing & Mau, 1993a). Each female lays about 14-26 eggs in a loose spiral on the underside of leaves (CABI, 2003). Eggs hatch in 7-11 days (Martin Kessing & Mau, 1993a; CABI, 2003). There are four larval stages (Martin Kessing & Mau, 1993a): the first instar lasts for 6-7 days; the second instar, 4 days; the third instar, 5-13 days; and the fourth (pupae), 5-16 days (CABI, 2003; Martin Kessing & Mau, 1993a). Adults live for about two weeks (CABI, 2003). During the immature stages, the first instar is capable of active movement (Martin Kessing & Mau, 1993a). Adults disperse beyond the leaf by flying; it is most active during the morning hours (Martin Kessing & Mau, 1993a). Long distance accomplished via the dissemination of infested plants and fruits (EPPO, 2004).	Medium (2)

Risk Element #4: Economic Impact *Aleurodicus dispersus* is a serious pest of tropical and subtropical crops (EPPO, 2004). The whitefly has high potential to have major economic impact due to polyphagous species. Economic damages that *A. dispersus* causes: (1) direct feeding damages on leaves, (2) indirect damages to excreted honeydew that encourages the development of sooty moulds and (3) a vector of plant diseases (CABI, 2003; Martin Kessing & Mau, 1993). Whiteflies cause over 40 plant diseases of vegetable and crops worldwide (Martin Kessing & Mau, 1993). *Aleurodicus dispersus* is a vector of the lethal yellowing virus of coconut palms in Florida (Akinolosotu *et al.*, 1993). *Aleurodicus dispersus* can damage 20 to 100% of crops depending on the crop, season, and prevalence (Martin Kessing & Mau, 1993). In Florida, *A. dispersus* has been reported on avocados, citrus, guavas and palms (CABI, 2003). Should *S. disperses* become established in the continental United states, it would likely result in the loss of foreign or domestic quarantine markets, due to the presence of a new quarantine pest.	High (3)
Risk Element #5: Environmental Impact *Aleurodicus dispersus* has a potential to damage Threatened and Endangered species, such as *Manihot walkerae* (Endangered species in TX), *Prunus geniculata* (Endangered species in FL), *Euphorbia telephioides* (Threatened species in FL), *Eugenia haematocarpa* (Endangered species in PR), *Eugenia woodburyana* (Endangered species in PR), *Rhododendron chapmanii* (Endangered species in FL), *Rorippa gambellii* (Endangered species in CA), *Solanum drymophilum* (Endangered species in PR), *Agave arizonica* (Endangered species in AZ), and *Amaranthus pumilus* (Threatened species in DE, MA, MD, NC, NJ, NY, RI, SC, VA) (USFWS, 2002). The establishment and introduction of *A. dispersus* in the continental United States would stimulate chemical or biological control programs. Successful biological controls have been established in Hawaii (CABI, 2003; Martin Kessing & Mau, 1993).	High (3)
Consequences of Introduction Risk Rating	**High (13)**

Consequences of Introduction: *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae)	Risk Value
Risk Element #1: Climate – Host Interaction *Bactrocera cucurbitae* is native to Asia and distributed throughout much of subtropical and tropical Asia. It is also reported as present in eastern and western Africa, and the Pacific Islands. (CABI 2002). Its distribution corresponds to U.S. Plant Hardiness Zones 9-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS 2002).	Medium (2)
Risk Element #2: Host Range *Bactrocera cucurbitae* is a serious pest of cucurbit crops (CABI, 2003). The primary host is **Cucurbitaceae** (*Cucumis melo*, *Cucurbita maxima*, *Cucurbita pepo*, *Trichosanthes cucumerina var. anguinea*) (CABI, 2003). Other host species include **Cucurbitaceae** (*Cucumis sativus*, *Benincasa hispida*, *Citrullus colocynthis*, *Citrullus lanatus*, *Cucumis auguria*, *Cucurbita moschata*, *Lagenaria siceraria*, *Luffa acutangula*, *Luffa aegyptiaca*, *Momordica balsamina*, *Momordica charantia*, *Sechium edule*, *Trichosanthes cucumerina*), **Moraceae** (*Artocarpus heterophyllus*, *Ficus carica*), **Malvaceae** (*Abelmoschus moschatus*), **Caricaceae** (*Carica papaya*), **Rutaceae** (*Citrus maxima*, *Citrus sinensis*), **Rosaceae** (*Cydonia oblonga*, *Prunus persica*), Solanaceae (*Cyphomandra betacea*, *Lycopersicon esculentum*), **Anacardiaceae** (*Mangifera indica*), **Sapotaceae** (*Manilkara zapota*), **Passifloraceae** (*Passiflora* spp., *Passiflora edulis*), **Lauraceae** (*Persea americana*), **Fabaceae** (*Phaseolus vulgaris*, *Sesbania grandiflora*, *Vigna unguiculata*), **Myrtaceae** (*Psidium guajava*, *Syzygium samarangense*), and **Rhamnaceae** (*Ziziphus jujube*) (CABI, 2003). Wild hosts of *B. cucurbitae* include the wild species of Cucurbitaceae, and rarely, fruits of other families: **Cucurbitaceae**: *Cucumis trigonus* (White and Elson-Harris, 1994), *Diplocyclos palmatus*, *Gymnopetalum integrifolium*, *Melothria wallichii*, *Mukia maderaspatana* (CABI, 2004), *Trichosanthes ovigera*, *T. tricuspidata*, *T. wallichiana* and *T. wawraei* (Allwood *et al.*, 1998; CABI, 2004); **Agavaceae**: *Dracaena curtissi* (Allwood *et al.*, 2000); *Capparidaceae: Capparis sepiaria*, *C. thorellii* and *Maerua siamensis* (Allwood *et al.*, 2000); **Moraceae**: *Ficus chartacea* (Allwood *et al.*, 2000); **Rutaceae***: Citrus hystrix* (Allwood *et al.*, 2000); **Solanaceae**: *Solanum trilobatum* (Allwood *et al.*, 2000); and **Vitaceae**: *Tetrastigma lanceolarium* (Allwood *et al.*, 2000).	High (3)
Risk Element #3: Dispersal Potential Females lay up to 40 eggs below the fruit skin or in the vegetative parts of plants. Females may produce 800-1000 eggs over their life span (Capinera, 2001; CABI, 2003; Weems, 1964). Reproduction is continuous as adults occur throughout the year. Under warm conditions, the development from egg to adult requires 12-28 days (Weems, 1964). Eggs hatch within 1-2 days, and larval stages last for 4-17 days, depending on the thickness of fruit skin (CABI, 2003). Pupation takes place in the soil under the host plants for 7-13 days (CABI, 2003). Adults start to mate after 10-12 days; they may live 5-15 months (CABI, 2003). This fruit fly may naturally disperse by flight (Fletcher, 1989); many Bactrocera species can fly 50-100 km. Additionally, *B. cucurbitae* can be dispersed by infected plant materials, such as fruits and flowers (CABI, 2003). In commodities originating from Hawaii, it has been intercepted at ports-of-entry over 150 times (USDA APHIS PPQ, 2005).	High (3)

Risk Element #4: Economic Impact *Bactrocera cucurbitae* has been considered the most destructive pest of cucurbits in the Indo-Malayan region (USDA 1983; Weems 1964); it has greatly reduced the production of melons, cucumbers, tomatoes, and similar vegetables in Hawaii (Capinera, 2001; Weems 1964). Around 1915, *B. cucurbitae* caused a loss of nearly $1 million in Hawaii, during which more than 95% of the pumpkin crop was destroyed. Damage levels have been reported to be anything up to 100% of unprotected fruit (CABI 2003). The establishment and introduction of *B. cucurbitae* in the continental United States would stimulate chemical or biological control programs. Additionally, EPPO (2004) records this as an A1 pest; thus, its establishment in the United States may lead to loss of export markets.	High (3)
Risk Element #5: Environmental Impact *Bactrocera cucurbitae* has a high potential to damage Threatened and Endangered species listed in Title 50, Part 17, Section 12 of the United States Code of Federal Regulations (50 CFR §17.12). Threatened and Endangered species, such as *Cucurbita okeechobeensis* spp. *okeechobeensis* (Endangered species in FL), *Prunus geniculata* (Endangered species in FL), and *Ziziphus celaata* (Endangered species in FL), are likely to be damaged by *B. cucurbitae* (USFWS, 2002). Since this fruit fly represents an important economic threat, the establishment and introduction of *B. cucurbitae* would probably trigger the initiation of biological and chemical controls to eradicate the fruit fly, similar to what has been done for other tephritid fruit fly introductions in the continental United States.	High (3)
Consequences of Introduction Risk Rating	**High (14)**

Consequences of Introduction: *Cryptophlebia ombrodelta* (Lepidoptera: Tortricidae)	Risk Value
Risk Element #1: Climate – Host Interaction *Cryptophlebia ombrodelta* has been reported in Bangladesh, Cambodia, China, Hong Kong, Indai, Indonesia, Japan, Laos, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam, Australia, Mariana Islands, Vanuatu, Papua New Guinea, Solomon Islands, and Hawaii (Zhang, 1994). Its current distribution corresponds to U.S. Plant Hardiness Zones 9-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS 2002).	Medium (2)
Risk Element #2: Host Range Primary hosts include **Bombacacea** (*Durio zibethinus*); **Fabaceae** (*Acacia* spp., *Adenanthera pavonina, Archidentron pauciflorum, Bauhinia purpuea, B. variegate, Caeslpinia decapetala, C. pulcherrima, Cassia* spp., *C. fistula, C. occidntalis, Parkia* spp., *Parkinsonia aculeate, Phaseolus* spp., *Senna occidentalis, Sesbania* spp., *Tamarindus indica*; *Vigna* spp.); **Palmae** (*Cocos nucifera*); **Polygonaceae** (*Coccoloba uvifera*); **Proteaceae** (*Macadamia* spp.); **Rhizophoraceae** (*Bruguiera gymnorhiza*); **Rutaceae** (*Aegle marmelos*, *Citrus* spp., *Limonia elephantum*); **Sapindaceae** (*Filicium decipiens, Litchi chinensis*); and **Sapotacea** (*Manikara zapota*) (Zhang, 1994; Robinson *et al*, 2001; CABI, 2004; Ironside, 1974; Chang, 1989)	High (3)
Risk Element #3: Dispersal Potential Ironside (1974) reported that in Australia, the life-cycle (egg to adult) of *Cryptophlebia ombrodelta* (Lower) was completed in five weeks in the summer on macademia nuts. In India, on tamarind pods, the insect completes its development from egg to adult in approximatedly 33.65 days. Females lay an average of 70 eggs with approximately 95.6% of the eggs hatching. In India, there are 3-4 generations per year (Lingappa & Siddappaji, 1981). Adults are fairly good fliers. Larvae are able to move from fruit to fruit (Lingappa & Siddappaji, 1981). They may also be dispersed by infected plant materials, such as fruits and pods.	High (3)
Risk Element #4: Economic Impact *Cryptophlebia ombrodelta* is one of the most important pests of macadamia nuts. In Australia, an infestation may cause crop losses of 60% or more due to larvae tunneling into the nuts (Ironside, 1982). In China, the combined damage caused by *C. ombrodelta* and *Eucoenogensus* spp., another pod borer, reached 89% (Ho, 1985). The larvae feed on the pulp of the fruit as they pass through it to reach the seed; they feed mainly on the seed, entering through the micropyle and leaving the seed-coat intact. Damaged fruits shrink and become brittle, as they remain on the tree until the following season. Around 37.6% of fruits were affected by the pest in the Bangalore area (Lingappa & Siddappaji, 1981). Because it is a citrus pest, and can thrive in citrus producing areas, the introduction of this pest into the United States would likely stimulate chemical or biological control programs and/or eradication programs; its establishment could lead to the loss of export markets.	High (3)

Risk Element #5: Environmental Impact Introductions of *L. boeticus* would likely result in the initiation of chemical or biological control programs. Based on its known host distribution, it is not likely to infest plants listed as Threatened or Endangered, except *Vigna o-wahuensis*, which is only reported in Hawaii (USDA NRCS 2002), where it is already present.	Medium (2)
Consequences of Introduction Risk Rating	**High (13)**

Consequences of Introduction: *Dysmicoccus neobrevipes* Beardsley (Homoptera: Pseudococcidae)	**Risk Value**
Risk Element #1: Climate – Host Interaction *Dysmicoccus neobrevipes* occurs throughout Central America, northern South America, the Caribbean, Indo-China, the Philippines, and Oceania (Miller & Miller, 2002; Scale Net, 2004; CABI, 2004). Outside of the greenhouse (or other artificial situations), this species is able to survive in the warmer, southern parts of the United States (Plant Hardiness Zones 9-11) (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS 2002).	Medium (2)
Risk Element #2: Host Range *Dysmicoccus neobrevipes* is highly polyphagous. Hosts include **Bromeliaceae** (*Ananas comosus*), **Rosaceae** (*Malus domestica*) (CABI, 2003), **Araceae** (*Colocasia esculenta*, *Pritchardia* sp.), **Moraceae** (*Ficus* sp.), **Musaceae** (*Musa paradisiaca*), **Cactaceae** (*Opuntia ficus-indica*), **Fabaceae** (*Acacia koa* , *Samanea saman*), **Asteraceae** (*Helianthus annuus*) (Nakahara, 1982); **Agavaceae** (*Agave sisalana*), **Cucurbitaceae** (*Cucurbita maxima*), **Poaceae** (*Zea mays*), **Heliconiaceae** (*Heliconia latispatha*), **Rutaceae** (*Citrus* spp.), and **Solanaceae** (*Lycopersicon esculentum*) (USDA APHIS PPQ, 2005).	High (3)
Risk Element #3: Dispersal Potential Ito (1938) reported females of the "gray form" of *D. brevipes* (considered by Beardsley [1959] to be *D. neobrevipes*) to produce an average of 347 progeny. The female life span averages about 95 days, with several generations per year indicated. As in all Coccoidea (Gullan & Kosztarab, 1997), the main dispersal stage of mealybugs is the first-instar crawler, which may be transported locally by wind or other animals. Dispersal over longer distances is accomplished through the movement of infested plant materials in commerce (CABI, 2004).	High (3)
Risk Element #4: Economic Impact *Dysmicoccus neobrevipes* attacks a number of valuable commercial crops, and is a particularly serious pest of pineapple, *Ananas comosus* (Rohrbach *et al*., 1988). Like *D. brevipes*, it is a vector of the virus causing pineapple wilt disease. Feeding by large mealybug populations may cause a loss of host plant vigor. Honeydew deposited on leaves and fruit (by mealybugs) serve as a medium for the growth of black sooty molds, which interfere with photosynthesis and reduce the market value of the crop. Insecticides are often applied to control mealybugs (or the attending ants) that aid in their spread of their biological control (Jahn *et al*., 2003). *Dysmicoccus neobrevipes* is a quarantine pest for Korea and New Zealand.	Medium (2)
Risk Element #5: Environmental Impact Further introductions of *D. neobrevipes* would likely result in the initiation of chemical or biological control programs, as has occurred in Hawaii and Puerto Rico (Bartlett, 1978). The species is polyphagous, and has the potential to infest plants listed as Threatened or Endangered (*e.g.*, *Opuntia treleasei* (CA), *Helianthus paradoxus* (NM, TX) (USFWS, 2002).	High (3)
Consequences of Introduction Risk Rating	**High (13)**

Consequences of Introduction: *Frankliniella schultzei* (Thysanoptera: Thripidae)	**Risk Value**
Risk Element #1: Climate – Host Interaction *Frankliniella schultzei* has a wide geographical distribution. It is found in both tropical and temperate climate zones, including Europe (Great Britain, Italy, and The Netherlands), Asia, Africa, Central America, the Caribbean, South America, Oceania, and Hawaii (CABI, 2004; Lewis, 1997; Kormelink, 2004). In North America, it is only found in Florida, where it is considered an actionable pest (Courneya, 2003; USDA APHIS PPQ, 2005). *Frankliniella schultzei* cannot over-winter in extremely cold climates; however, regions with cold winters can become reinfested with *F. schultzei* from greenhouse populations. Its distribution corresponds to U.S. Plant Hardiness Zones 5b-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS 2002).	High (3)
Risk Element #2: Host Range Major hosts of this species: **Bromeliaceae** (*Ananas comosus*), **Fabaceae** (*Arachis hypogaea, Cajanus cajan, Glycine max, Lens culinaris* ssp. *Culinaris, Vigna mungo , Vigna unguiculata*) **Malvaceae** (*Gossypium* sp), **Liliaceae** (*Hyacinthus* sp.), **Asteraceae** (*Lactuca sativa*), and **Solanaceae** (*Lycopersicon esculentum, Nicotiana tabacum*). Minor hosts include **Cactaceae** and **Gesneriaceae** (*Saintpaulia ionantha*) (CABI, 2004).	High (3)
Risk Element #3: Dispersal Potential *Frankliniella schultzei* inserts eggs into the tissue of green plants that hatch in 6-8 days. On cotton, females oviposit approximately 25 eggs during their adult life. Typical developmental times on cotton (28°C day/21°C night) for first-instar larvae, second-instar larvae, pre-pupa and pupa are 6-8, 6-8, 2-4 and 2-4 days, respectively (CABI, 2004). Like most thrips, *F. schultzei* is a weak flyer; however, its fringed wings enable it to remain airborne long enough to travel between neighboring fields, and frequently, large distances. This species can be transported in commercial commodities, including fresh fruits and vegetables, cut flowers and plants for planting (Lewis, 1997).	High (3)
Risk Element #4: Economic Impact *Frankliniella schultzei* can cause both direct and indirect damage to host plants. Direct damage is caused by suction injury and by eggs being laid in leaves. Pale spots and stripes on flowers of many different plants can be the result of suction activity of the thrips. On fruits and pods, *F. schultzei* may cause lesions, abnormal shape, and premature drop (CABI, 2004). *Frankliniella schultzei* is a major pest of cotton in Argentina and Paraguay; large numbers of emerging plants can be destroyed by this species. Feeding on young cotton plants causes symptoms of deformation (CABI, 2004). In cotton, *F. schultzei* causes deformation and destruction of young plants and seedlings. In southern Iran, it has been reported to injure cotton flowers and cause withered spots or wounds in the boll pericarp. In the Netherlands, *F. schultzei* is a noxious pest of hyacinth bulbs during propagation (CABI, 2004). Studies carried out in the fields of *Phaseolus vulgaris* in Argentina showed that *F. shultzei* was one of the most damaging thrips species, causing significant losses from the emergence to pod formation (Agostini de Manero *et al*, 1990).	Medium (2)

Frankliniella schultzei causes severe indirect damage to plants as a vector of several important plant tospoviruses. These viruses are considered limiting factors in the production of a large number of horticultural crops. *Frankliniella schultzei* is a vector of tomato spotted wilt tospovirus (TSWV), tomato chlorotic spot tospovirus (TCSV), groundnut ringspot tospovirus (GRSV), and tobacco streak ilarvirus (TSV) (CABI, 2004; Lewis, 1997; Kormelink, 2004). Expansion and spread into additional areas of the continental United States would stimulate chemical or biological control programs, increasing production costs. As it is established in parts of Florida, and under no apparent official control, further introductions of the thrips are considered unlikely to result in the loss of foreign markets.	
Risk Element #5: Environmental Impact Further introductions of *F. schulzei* would likely result in the initiation of chemical or biological control programs. This species is polyphagous. Based on its known host distribution, it is not likely to infest plants listed as Threatened or Endangered , except *Vigna o-wahuensis*, which is only reported to be in Hawaii (USDA NRCS 2002), as it is already present there.	Medium (2)
Consequences of Introduction Risk Rating	**High (13)**

Consequences of Introduction: *Lampides boeticus* (Lepidoptera: Lycaenidae)	**Risk Value**
Risk Element #1: Climate – Host Interaction This pest is widespread throughout western Europe (from UK, Danmark, France to more southern Portugal, Italy, Greece), Africa, Oceania (including Hawaii) and southern Asia. It is not established in cooler temperate regions, such as central and northern Europe. Its distribution corresponds to U.S. Plant Hardiness Zones 7-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS 2002).	High (3)
Risk Element #2: Host Range *Lampides boeticus* is primarily a pest of beans (Family: **Fabaceae**.) Hosts include *Cajanus cajan, Canavalia* sp., *Cicer arietinum, Crotalaria juncea*, *Glycine max*, *Lablab purpureus*, *Medicago sativa*, *Phaseolus lunatus*, *Phaseolus vulgaris*, *Pisum sativum*, *Pisum sativum* var. *arvense, Psophocarpus* spp., *Pueraria phaseoloides*, *Sesbania sesban*, *Vicia faba*, *Vigna mungo*, *Vigna radiata*, and *Vigna unguiculata*. Wild hosts include *Cytisus* spp., *Cytisus scoparius*, *Sesbania tomentosa* , *Sophora chrysophylla*, *Ulex europaeus* (gorse), *Vicia sativa* (common vetch), *Vigna vexillata*, and *Viminaria juncea*, all of which are in the family **Fabaceae** (CABI, 2004).	Medium (2)
Risk Element #3: Dispersal Potential *Lampides boeticus* is a migrant, capable of long distance movement, often involving vast numbers of individuals (CABI, 2004). It is a multivoltine species with a high reproductive potential and more than three generations per year (Takenari, 2003; Kitahara, 2004). This species can be transported in commercial commodities, including fresh fruits and vegetables, cut flowers, and plants for planting; it has been intercepted several times at U.S. ports-of-entry (USDA, 2005).	High (3)
Risk Element #4: Economic Impact *Lampides boeticus* is usually a minor pest that has the potential to be serious. For example, it is one of the most damaging pests of pigeon pea, *Cajanus cajan*, a legume often grown in tropical areas (CABI, 2004). In Hawaii, it is a major pest of garden beans, and can cause considerable damage to local crops if not controlled (Zimmerman, 1958; CABI, 2004). The incidence of *L. boeticus* on peas was studied in Haryana, India in 1981. Damage to pods and locules averaged 8%, which was high enough for the pest to be regarded as serious (CABI, 2004). The introduction and establishment of *L. boeticus* in the continental United States would likely stimulate chemical or biological control programs, which, in turn, could increase the cost of production.	Medium (2)

Risk Element #5: Environmental Impact The introduction of *L. boeticus* would result in the initiation of chemical or biological control programs. Based on its known host distribution, it is not likely to infest plants listed as Threatened or Endangered, except *Vigna o-wahuensis*, which is only reported in Hawaii (USDA NRCS 2002), where *L. boeticus* is already present.	Medium (2)
Consequences of Introduction Risk Rating	**Medium (12)**

Consequences of Introduction: ***Maconellicoccus hirsutus*** **(Green) (Homoptera: Pseudococcidae)**	**Risk Value**
Risk Element #1: Climate – Host Interaction *Maconellicoccus hirsutus* is native to southern Asia (CABI, 2003). It is reported in northern and part of sub-Saharan Africa, the Middle East, south and southeast Asia, the Far East, Central America, Australia and Oceania (CABI 2003). Currently, this pest has a limited distribution in the United States (Hawaii, California, and Florida) (Hoy *et al* 2003, Capinera, 2001). It is estimated that it could potentially establish in the United States in the Plant Hardiness Zones 9-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these zones (USDA NRCS 2002).	Medium (2)
Risk Element #2: Host Range This species is extremely polyphagous. It has been recorded on plants in over 200 genera from 73 families, showing some preference for hosts in the Malvaceae, Fabaceae, and Moraceae (CABI, 2003). Hosts include **Acanthaceae** (*Acanthus ilicifolius, Eranthemum pulchellum, Pachystachys lutea, Thumbergia erecta*), **Amaranthaceae** (*Achyranthes indica, Amaranthus* spp., *Celosia cristata*), **Amaryllidaceae** (*Calostemma* spp.) **Anacardiaceae** (*Mangifera indica, Schinus* spp., *Spondias* spp.), **Annonaceae** (*Annona* spp., *Canaga odorata*), **Apiaceae** (*Daucus carota*), **Apocynaceae** (*Allamanda* spp., *Carissa* spp., *Catharanthus roseus, Ervatamia coronaria, Nerium* spp., *Tabernamontana divaricata, Vinca minor*), **Araceae** (*Aglaonema* spp., *Alocasia cucullata, Anthurium andraeanum, Colocasia esculenta, Dieffenbachia* spp., *Philodendron* spp., *Scindapsus aureus, Syngonium podophyllum, Xanthosoma* spp.), **Araliaceae** (*Aralia* spp., *Brassaia actinophylla, Schefflera* spp., *Sciadophyllum pulchrum*), **Basellaceae** (*Basella alba*), **Begoniaceae** (*Begonia* spp.), **Bignoniaceae** (*Bignonia* spp., *Crescentia cujete, Jacaranda mimusifolia, Kigelia* spp., *Tabebuia* spp., *Tecoma* spp.), **Bombacaceae** (*Ceiba pentandra*), **Boraginaceae** (*Cordia curssavica*), **Cactaceae** (*Opuntia* spp., *Pereskia bleo*), **Caricaceae** (*Carica papaya*), **Casuarinaceae** (*Casuarina* spp.), **Chenopodiaceae** (*Beta vulgaris, Chenopodium, album*), **Combretaceae** (*Quisqualis* sp., *Rhoeo* sp., *Terminalia* spp.), **Compositae** (*Bidens pilesa, Chrysanthemum coronarium, Cosmos* spp., *Dahlia* spp., *Emilia* sp., *Gerbera* spp., *Helicanthus annuus, Lactuca sativa, Mikania cordata, Parthenium hysterophorus, Symedrella nodifloa, Tithonia urticifolia*), **Convolvulaceae** (*Ipomoea* spp.), **Crassulaceae** (*Kalanchoe* sp.), **Cucurbitaceae** (*Cucumis* spp., *Cucurbita* spp.), **Cyperaceae** (*Cyperus* spp.), **Dilleniaceae** (*Tetracera* spp.), **Dioscoraceae** (*Dioscorea* spp.), **Ebenaceae** (*Diospyros kaki*), **Euphorbiaceae** (*Acalypha* spp., *Codiaeum* sp., *Croton* spp., *Euphorbia* spp., *Hevea* spp., *Macarangua* sp., *Manihot esculenta., Ohyllanthus amarus, Phyllanthus* spp., *Ricinus communis*), **Fabaceae** (*Acacia arabica, Albizia* spp., *Arachis hypogaea, Bauhinia* spp., *Caesalpinia* spp., *Cajanus* spp., *Calliandra* spp., *Cassia* spp., *Ceratonia siliqua, Clitoria ternatea, Crotalaria* sp., *Erythrina* spp., *Gliricidium sepium, Glycine max, Grewia* sp., *Inga* sp., *Leucaena glauca, Medicago sativa, mimosa pudica, Parkinsonia aculeate, Phaseolus mungo, Phaseolus vulgaris, Poinciana regia, Robinia pseudacacia, Samanea saman, Sena* spp., *Sesbania aegyptiaca, Tamarindus indica, Templetonia* sp., *Tephrosia* sp., *Vigna unguiculata*), **Fagaceae** (*Pasania* spp., *Quercus* spp.) **Flacourtiaceae** (*Flacourtis indica*), **Gesneriacae** (*Chrysothemis pulchella*), **Gramineae** (*Saccharum officinarum, Zea mays*), **Lamiaceae** (*Clerodendrum aculeatum, Leonotis nepetifolia*), **Lauraceae** (*Persea americana*), **Lecythidaceae** (*Courouptia guianensis*), **Liliaceae** (*Asparagus* spp., *Cordyline terminalis, Dracaena* spp.), **Lythraceae** (*Lagerstroemia speciosa, Lawsonia* spp.), **Malvaceae** (*Abelmoschus esculentus, Abutilon indicum, Gossypium* spp., *Hibiscus* spp., Holmskia sanguinea, Malvaviscus arboreus, Paritium spp., *Pavonia* spp., *Thespesia* spp.), **Melastomataceae** (*Miconia cornifolia*), **Meliaceae** (*Azadirachta indica, Ficus*	High (3)

spp., *Morus* spp.), **Moraceae** (*Heliconia* spp., *Musda sp*), **Myrtaceae** (*Callistemon* spp., *Eugenia* spp., *Myrtus communis*, *Psidium guajava*, *Syzygium* spp.), **Nyctaginaceae** (*Bougainvillea* spp.), **Oleaceae** (*Jasminum* spp.), **Orchidaceae** (*Dendrobium* spp.), **Oxalidaceae** (*Averrhoa carambola*), **Palmae** (*Cocos nucifera*, *Phoenix* spp.), **Passifloraceae** (*Passiflora* spp.), **Phytolacaceae** (*Rivina humilis*, *Petiveria alliacea*), **Piperaceae** (*Peperomia pellucida*, *Piper tuberculatum*), **Plumbaginaceae** (*Plumbago auriculata*), **Polygonaceae** (*Cocoloba uvifera*, *Nephrolepis* spp.), **Portulacaceae** (*Portulaca* spp.), **Proteaceae** (*Grevillea robusta*), **Rhamnaceae** (*Colubrina arborescens*, *Ziziphus* spp.), **Rosaceae** (*Crataegus* spp., *Cydonia oblonga*, *Eriobotra japonica*, *Prunus* spp., *Pyrus* spp., *Rosa* sp.), **Rubiaceae** (*Coffea* spp., *Haldina cordifolia*, *Hamelia* spp., *Ixora* spp.), **Rutaceae** (*Aegle marmelos*, *Citrus* spp., *Murraya* spp., *Mussaenda* sp.), **Salicaceae** (*Salix* spp.), **Sapindaceae** (*Blighia sapida*, *Dodonaea viscose*, *Melicocca* spp.), **Sapotaceae** (*Manilkara zapota*), **Scrophulariaceae** (*Russelia equisetifolia*, *Scoparia dulcis*), **Solnaceae** (*Capsicum* spp., *Cestrum nocturnum*, *Datura* spp., *Lycopersicon esculentum*, *Solanum* spp.), **Sterculiaceae** (*Theobroma cacao*), **Tiliaceae** (*Corchorus olitorius*), **Urticaceae** (*Boehmeria nivea*, *Laportea aestuans*), **Verbenaceae** (*Tectona grandis*), **Vitaceae** (*Cissus verticillata*, *Vitis vinifera*), and **Zigiberaceae** (*Alpinia* spp.) (Scale Net, 2004).	
Risk Element #3: Dispersal Potential Each adult female can lay from 80 to 600 eggs over a one week period (Meyerdirk *et al*, 1996; CABI, 2004). Hatching occurs in 6-9 days (CABI, 2004). In warm conditions, a generation is completed in five weeks; in colder climates, the species can survive cold conditions (especially as eggs) on the host plant or in the soil. There may be as many as 15 generations per year. Local dispersal is accomplished by the first-instar crawler via air, water, or on animals (CABI, 2004). All stages may be dispersed over longer distances through the transport of infested plant materials (USDA APHIS PPQ, 2005).	High (3)
Risk Element #4: Economic Impact *Maconellicoccus hirsutus* attacks a wide range of (usually woody) plants, including agricultural, horticultural, and forest species (CABI, 204). Feeding on young growth causes severe stunting and distortion of leaves, thickening of stems, and a bunchy-top appearance of shoots; in severe cases the leaves may prematurely fall. Honeydew and sooty mold contamination of fruit may reduce its value. In Grenada, estimated annual losses to crops and the environment from this mealybug were \$3.5 million before biological controls were implemented (CABI, 2004). Other crops seriously damaged by *M. hirsutus* include cotton in Egypt, with growth sometimes virtually halted; tree cotton in India, with reduction in yield; the fiber crop *Hibiscus sabdariffa* var. *altissima* (roselle) in India and Bangladesh, with reduction in yields of between 21 and 40%; and grapes in India, with up to 90% of bunches destroyed. It is a quarantine pest for Brazil, Chile, Colombia, Costa Rick, Korea, New Zealand, Panama, and Uruguay (PRF, 2004), suggesting that its widespread establishment in the United States could result in a loss of foreign markets for various commodities. This species is an actual or potential pest of a wide range of economically important plants, and risk associated with its economic impact is estimated to be High. EPPO (2004) records this as an A1 pest; thus, establishment in the United States may lead to loss of export markets.	High (3)
Risk Element #5: Environmental Impact Because of its extreme polyphagy, this pest poses a threat to plants in the continental United States listed as Threatened or Endangered, including *Cucurbita okeechobeensis* ssp. *Okeechobeensis* (FL), *Helianthus eggertii* (AL,KY, TN), *H. paradoxus (TX), H. schweinitzii (NC, SC), Manihot walkerae (TX), Opuntia treleasei (CA), Rhododendron chapmanii (FL),*	High (3)

Amaranthus pumilus (DE, MA, MD, NC, NJ, NY, RI, SC, VA), Euphorbia telephiodes (FL), Prunus geniculata (FL), (USFWS, 2003). As it also is a potential threat to a number of crops of considerable economic value in the United States (*e.g.*, soybean, cotton, corn, citrus, grapes; CABI, 2003), its introduction into additional mainland states would likely lead to the initiation of chemical or biological control programs. Currently, this species is the target of an official program of biological control throughout its present range in the United States (Meyerdick *et al*, 2003), and has been targeted for biological control in other countries, such as Egypt and India (Bartlett, 1978).	
Consequences of Introduction Risk Rating	**High (14)**

<table>
<tr><th>Consequences of Introduction: Maruca vitrata Fabricius (Lepidoptera: Pyralidae)</th><th>Risk Value</th></tr>
<tr><td>Risk Element #1: Climate – Host Interaction

Maruca vitrata is distributed throughout tropical regions (CABI, 2003). This species is found in Africa, South America, south Asia, and the Pacific Islands; it will not survive in temperate regions (CABI, 2003). Its distribution corresponds to U.S. Plant Hardiness Zones 9-11 (USDA ARS, 1990).</td><td>Medium (2)</td></tr>
<tr><td>Risk Element #2: Host Range

Maruca vitrata is a serious pest of leguminous species. Host species are limited to Fabaceae (Caesalpinia spp., Cajanus spp., Cajanus cajan, Canavalia spp., Canavalia ensiformis, Crotalaria spp., Derris spp., Glycine spp., Phaseolus spp., Phaseolus lunatus, Phaseolus vulgaris, Tephrosia spp., Vigna spp., Vigna unguiculata, Lablab purpureus, and Pueraria phaseoloides) (CABI, 2004).</td><td>Medium (2)</td></tr>
<tr><td>Risk Element #3: Dispersal Potential

The biology of M. vitrata varies with diet conditions and locations; however, there are seven generations per year in China (CABI, 2004). Females lay their eggs individually on flowers or flower buds; fecundity is about 200 eggs (CABI, 2004). The egg period lasts an average of three days at 24-27°C (CABI, 2004).

The first instar mainly feeds on flowers, damaging 4-6 flowers each; this instar will also feed on leaves (CABI, 2004). The later instars feed on pods and fruits (CABI, 2004). The larval stage lasts an average of 13-14 days at 24-27°C (CABI, 2003). The pre-pupal stage lasts an average of 1-2 days, and the pupal stage lasts 6-7 days (CABI, 2003). The adult stage lasts about 6-10 days (CABI, 2004).

This species may be dispersed over longer distances through the transport of infested plant materials and has been intercepted at U.S. ports-of-entry several times (USDA APHIS PPQ, 2005).</td><td>High (3)</td></tr>
</table>

Risk Element #4: Economic Impact As a serious pest of beans, *Maruca vitrata* has high potential for great impact on U.S. agriculture. Damage varies with location. In some places, more than 50% of bean products were damaged by *M. vitrata* (CABI, 2003). In Hawaii, *M. vitrata* is one of the most destructive pests of beans (Anonymous, 2004); it causes yield loss, and increases the cost of production via the usage of pesticides. This species is predicted to have a great impact on legume crops in southern United States (Anonymous, 2004). The establishment of this pest in the United States could lead to the loss of export markets, particularly Europe.	High (3)
Risk Element #5: Environmental Impact *Maruca vitrata* may impact *Crotalaria avonensis*, an Endangered species from Florida listed in Title 50, Part 17, Section 12 of the United States Code of Federal Regulations (50 CFR §17.12). Other species, such as *Caesalpinia kavaiense*, *Canavalia molokaiensis* and *Vigna o-wahuensis*, are only reported in Hawaii (USDA NRCS 2002), where *M. vitrata* is already present. Chemical and biological control are likely to be implemented upon introduction of *M. vitrata* similar to programs that exist in Asia, Africa, and Hawaii (CABI, 2003).	High (3)
Consequences of Introduction Risk Rating	**High (13)**

Consequences of Introduction: *Oligonychus biharensis* Hirst (Acari: Tetranychidae)	**Risk Value**
Risk Element #1: Climate – Host Interaction Apart from Hawaii, this species occurs in India, Thailand (Bolland *et al*., 1998), and Oceania (CABI, 2003). Based on this distribution, it is estimated that it would be able to establish in the southern continental United States (Plant Hardiness Zones 9-11) (USDA ARS, 1990)	Medium (2)
Risk Element #2: Host Range *Oligonychus biharensis* has been recorded on **Malvaceae** (*Abelmoschus esculentus*), **Fabaceae** (*Arachis hypogaea*, *Phaseolus vulgaris*, *Vigna unguiculata*), **Arecaceae** (*Cocos nucifera*), Myrtaceae (*Eucalyptus* sp.), **Mimosaceae** (*Leucaena* sp.), **Euphorbiaceae (***Manihot esculenta*), **Musaceae** (*Musa* sp.), and **Rosaceae** (*Rosa* sp.) (CABI, 2004; Bolland *et al*, 1998).	High (3)
Risk Element #3: Dispersal Potential As in all spider mites (Tetranychidae), long-distance dispersal would occur by wind-borne individuals and via the movement of infested plant materials (Jeppson *et al*., 1975). Reproductive capacity is highly variable among species of *Oligonychus*, some exhibiting as many as 30 generations per year (*e.g.*, *O. grypus)* (Jeppson *et al*., 1975). The reproductive potential of *O. biharehsis* depends on the temperature: doubling rate was 29.5 days at 15^{o}C and 2.2 days at 35^{o}C; the highest mean number of eggs per female was 71.6 and daily oviposition rate 4.1 eggs per female was observed at 25 ^{o}C. Higher temperatures are more favourable for this insect (Ji Jie *et al*., 2005). Host plant qualities also affect the rate of development; on different varieties of litchi, oviposition varied from 68.8 to 34.0 eggs per female. The daily oviposition rate differed from 5.3 to 1.7 eggs (Wanmei Chen *et al*., 2005)	High (3)
Risk Element #4: Economic Impact Little information is available on the pest status of this mite. Reportedly, *O. biharensis* has the ability to devitalize the tender parts of plants, but estimates of yield losses could not be found. The mite sucks leaf sap, causing premature leaf fall; this results in fruit of poor quality with poor flavor and a lower yield of the crop (Cai-ZiJian & Wen-ShouXing, 2002). It is a pest of many economically important horticultural and agricultural crops, such as *Phaseolus vulgaris* and *Rosa*. Should this species establish in the United States, chemical control programs would probably be initiated. It is an important pest of loquat in China. Insecticides are used to control this pest, which, in turn, increases the cost of production. It is unlikely that its establishment in the continental United States would lead to the loss of export markets.	Medium (2)
Risk Element #5: Environmental Impact From the list of United States Threatened or Endangered species, it is likely that *O. biharensis* can attack *Manihot walkerae* (TX); however, the introduction of the mite into production areas could lead to the initiation of biological control programs similar to those targeting other tetranychid mites (McMurtry, 1985).	Medium (2)
Consequences of Introduction Risk Rating	**Medium (12)**

Consequences of Introduction: *Spodoptera litura (Fabricius)*(Lepidoptera: Noctuidae)	**Risk Value**
Risk Element #1: Climate – Host Interaction *Spodoptera litura* is widely distributed throughout tropical and temperate Asia, Australia, and the Pacific Islands. This distribution corresponds to U.S. Plant Hardiness Zones 7-11 (USDA ARS, 1990). One or more of its potential hosts occurs in these Zones (USDA NRCS 2002).	High (3)
Risk Element #2: Host Range *Spodoptera litura* has an extremely wide host range. Hosts include **Malvaceae** *(Abelmoschus esculentus, Gossypium* spp.*)*, **Fabaceae** *(Acacia mangium, Arachis hypogaea, Cicer arietinum, Crotalaria juncea, Glycine max, Lathyrus odoratus, Medicago sativa, Phaseolus* spp., *Psophocarpus tetragonolobus, Ricinus communis, Trigonella foenum-graecum, Vigna mungo, Vigna unguiculata*), **Liliaceae** (*Allium cepa, Gladiolus hybrids, Lilium* spp.), **Amaranthaceae** *(Amaranthus)*, **Chenopodiaceae** *(Beta vulgaris var. saccharifera)*, **Urticaceae** (*Boehmeria nivea*), **Brassicaceae** (*Brassica oleracea* var. *botrytis, Brassica oleracea* var. *capitata, Raphanus sativus*), **Theaceae** (*Camellia sinensis*), **Solanaceae** (*Capsicum frutescens, Lycopersicon esculentum, Nicotiana tabacum, Solanum tuberosum*), **Rutaceae** (*Citrus* spp.) **Rubiaceae** (*Coffea* spp.), **Araceae** (*Colocasia esculenta*), **Tiliaceae** (*Corchorus* spp.), **Apiaceae** (*Coriandrum sativum, Foeniculum vulgare*), **Asteraceae** (*Cynara scolymus, Helianthus annuus, Zinnia elegans*), **Rosaceae** (*Fragaria ananassa, Malus pumila, Rosa* spp.), **Euphorbiaceae** (*Hevea brasiliensis, Jatropha curcas, Manihot esculenta*) **Convolvulaceae** (*Ipomoea batatas*), Linacae (*Linum usitatissimum*), **Moraceae** (*Morus alba*), **Musaceae** (*Musa* spp.), **Poaceae** (*Oryza sativa*) **Papaveraceae** (*Papaver* spp.), **Scrophulariaceae** (*Paulownia tomentosa*), **Piperaceae** (*Piper nigrum*), *Sesbania grandiflora (agati), Solanum melongena (aubergine)*, **Poaceae** (*Sorghum bicolor, Zea mays*), **Myrtaceae** (*Syzygium aromaticum*), **Verbenaceae** (*Tectona grandis*), **Sterculiaceae** (*Theobroma cacao*), and **Vitaceae** (*Vitis vinifera*) (Pouge, 2003, CABI, 2004).	High (3)
Risk Element #3: Dispersal Potential A mark-recapture experiment on *S. litura* to measure its migratory ability suggested an average male dispersion distance of 4-6 km a day, with a maximum of 18 km (Saito, 2000). Other studies have demonstrated that females have an ability to fly up to 8 km/day and males up to 10 km (Saito, 2000). Larvae may be spread while in fruits (EPPO/CABI, 1997). Fecundity may be as high as 2,600 eggs per female, with up to 12 generations per year (CPC, 2003).	High (3)
Risk Element #4: Economic Impact In India, crop yield loss was estimated at over 40% because of this pest. In Japanese greenhouses, there was a 10% yield loss in peppers (EPPO/CABI, 1997). Similar losses may be expected on crops in the PRA area. Costs of production are greatly increased as a result of the costs of controlling this pest. EPPO (2004) records this as an A2 pest; thus, its establishment in the United States may lead to the loss of export markets.	High (3)

Risk Element #5: Environmental Impact *Spodoptera litura* may impact several Endangered species listed in Title 50, Part 17, Section 12 of the United States Code of Federal Regulations (50 CFR §17.12), including *Allium munzii*, *Amaranthus brownie, A. pumilus*, *Helianthus eggertii*, *Helianthus paradoxus, H. schweinitzi, Solanum drymophilumi* (PR) and *S. sandwicense* . Other species, such as *Sesbania tomentosa*, *Solanum incompleturn* and *Vigna o-wahuensis*, are reported only in Hawaii (USDA NRCS 2002), where *S. litura* is already present. Chemical and biological control are likely to be implemented upon the introduction of *S. litura*.	High (3)
Consequences of Introduction Risk Rating	**High (15)**

Consequences of Introduction: *Thrips palmi* Karny (Thysanoptera: Thripidae)	**Risk Value**
Risk Element #1: Climate – Host Interaction *Thrips palmi* is subtropical to tropical in distribution; populations in temperate climates are able to overwinter in greenhouses or other artificial situations since it cannot survive subzero temperatures for more than a few days (Lewis, 1997; CABI, 2003). This thrips occurs in Asia, (Pakistan to Indonesia), parts of the tropical Pacific and Africa, and, recently, in the Caribbean and northern South America. United States populations are restricted to American Samoa, southern Florida, Guam, Hawaii and Puerto Rico (CABI 2003). Based on this distribution, it is estimated that *T. palmi* could establish permanent outside populations in the United States in U.S. Plant Hardiness Zones 9-11 (Figure 1). One or more of its potential hosts occur in these zones (USDA-NRCS 2003).	Medium (2)
Risk Element #2: Host Range *Thrips palmi* is a polyphagous pest that attacks plants in the families Anacardiaceae, Asteraceae, Cucurbitaceae, Fabaceae, Lauraceae, Liliaceae, Malvaceae, Orchidaceae, Pedaliaceae, Poaceae and Solanaceae (CABI 2003). Among primary hosts are species of Cucurbitaceae and Solanaceae, including *Cucurbita pepo* and *Solanum melongena.* The thrips also has been recorded on **Liliaceae** (*Allium cepa*), **Asteraceae** (*Helianthus annuus*), **Rutaceae** (*Citrus* spp.), **Fabaceae** (*Glycine max*, *Vigna* spp.) **Malvaceae,** (*Gossypium* sp.), **Anacardiaceae** (*Mangifera indica*), **Poaceae** (*Oryza sativa*), **Lauraceae** (*Persea americana*), and **Pedaliaceae** (*Sesamum indicum*) (CABI, 2004).	High (3)
Risk Element #3: Dispersal Potential Female *T. palmi* can mature and deposit up to 204 eggs during their life; generation times range from 11.5-20 days, depending on the temperature and host plant (Capinera 2000; CABI 2003). Several generations per year are possible. Originally restricted to south and southeast Asia, over the past 25 years, *T. palmi* has rapidly spread to Australia, Africa, and the Western Hemisphere (CABI, 2003). Bournier (1986) suggested that rapid, long-distance dispersal is facilitated by wind and aircraft transport of infested plant materials. Adults are capable of flight, and their small size and fringed wings allow long distance dispersal via wind or as passengers in commercial commodities (Lewis 1997). The species has been intercepted over 8100 times at U.S. ports during the last 20 years (USDA, 2005); thus, this pest exhibits high reproductive and dispersal capacities.	High (3)
Risk Element #4: Economic Impact *Thrips palmi* is a serious pest of cucurbits and eggplant. Losses of 50-90% in these crops have been reported (CABI, 2003). On cucumber, feeding stunts plants, causing premature bud and fruit drop, and deforming fruits that survive; infestations can be as low as one thrips per leaf, which results in fewer tendrils and leaves, and dead plants (Lewis, 1997). The species is a vector of tomato spotted wilt tospovirus (CABI, 2003). It is difficult to control chemically, requiring repeated applications of insecticides to achieve acceptable levels of control (Sakimura *et al.*, 1986). As it is listed by EPPO as an A1 quarantine pest for Europe (CABI/EPPO, 1997), its establishment in the United States could result in the loss of foreign markets for various agricultural commodities.	High (3)

Risk Element #5: Environmental Impact This pest has the potential to attack plants listed as Endangered or Threatened in the United States (*e.g.*, *Allium munzii* (CA), *Cucurbita okeechobeensis* ssp. *okeechobeensis* (FL), *Helianthus* spp. three species in AL, KY, NC, NM, SC, TN, TX.). Its introduction would undoubtedly initiate control programs in areas of the United States to which it was newly introduced because it is a major pest of numerous economic crops (*e.g.*, beans, peppers and tomatoes). Similar programs have been considered in other countries (*e.g.*, Japan) (Hirose *et al*., 1993). At present, biological control of *T. palmi* cannot be achieved; preliminary studies have been carried out concentrating on *Orius* sp. (Hemiptera: Anthocoridae) and *Amblyseius* spp. (Acarina: Phytoseiidae) (EPPO, 2004).	High (3)
Consequences of Introduction Risk Rating	**High (14)**

Table 5. Risk Rating for Consequences of Introduction of Cowpea, *Vigna unguiculata*						
Pest	**RE #1: Climate/Host Interaction**	**RE #2: Host Range**	**RE #3: Dispersal Potential**	**RE #4: Economic Impact**	**RE #5: Environ. Impact**	**Cumulative Risk Rating**
Aleurodicus dispersus	Medium (2)	High (3)	Medium (2)	High (3)	High (3)	**High (13)**
Bactrocera cucurbitae	Medium (2)	High (3)	High (3)	High (3)	High (3)	**High (14)**
Cryptophlebia ombrodelta	Medium (2)	High (3)	High (3)	High (3)	Medium (2)	**High (13)**
Dysmicoccus neobrevipes	Medium (2)	High (3)	High (3)	Medium (2)	High (3)	**High (13)**
Frankliniella schultzii	High (3)	High (3)	High (3)	Medium (2)	Medium (2)	**High (13)**
Lampides boeticus	High (3)	Medium (2)	High (3)	Medium (2)	Medium (2)	**Medium (12)**
Maconellicoccus hirsutus	Medium (2)	High (3)	High (3)	High (3)	High (3)	**High (14)**
Maruca vitrata	Medium (2)	Medium (2)	High (3)	High (3)	High (3)	**High (13)**
Oligonychus biharensis	Medium (2)	High (3)	High (3)	Medium (2)	Medium (2)	**Medium (12)**
Spodoptera litura	High (3)	High (3)	High (3)	High (3)	High (3)	**High (15)**
Thrips palmi	Medium (2)	High (3)	High (3)	High (3)	High (3)	**High (14)**

2.6 Likelihood of Introduction

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 in Table 6.

Quantity imported annually

The rating for the quantity imported annually is based on the amount reported by the exporter, and is converted into standard units of 40-foot-long shipping containers. Based on current production levels in Hawaii, the projected initial volume of cowpea pods to be shipped from Hawaii to the continental United States is estimated to be fairly small. Current production does not render enough to fill a single standard 40-foot-long shipping container; therefore, this element is ranked Low for all pests.

Survive post-harvest treatment

Bactrocera cucurbitae, Lampides boeticus, and *Maruca vitrata* are internal feeders that are expected to survive minimal post-harvest treatment, such as washing and culling, especially at the very early stage of infestation when damage indexes are not obvious. *Spodoptera litura* adults prefer to lay eggs on leaves, and the ensuing feed on leaves and, occasionally, on young pods; however, larvae are large and would low probability of surviving washing and culling.

Cryptophlebia ombrodelta larvae are large and gregarious, move actively between fruit, and have noticeable feeding damage.

The remaining pests are all external, and have a Low probability of surviving the post-harvest procedures of washing and culling. Cowpea pods are smooth and do provide suitable shelter for external pests.

Survive shipment

According to the USDA Tropical Products Transport Handbook, Chinese long beans, asparagus beans, and cowpeas (*Vigna unguiculata*) are typically shipped at 39-45ºF at a relative humidity of 90-95%. Chilling injury typically occurs at 38ºF. Transit and storage life is typically 7-10 days. Under these conditions, it is likely that all of the pests could survive shipment; thus, all pests are rated High (3).

Additionally, *Bactrocera cucurbitae*, *Aleurodicus dispersus*, *Dysmicoccus neobrevipes*, *Maconellicoccus hirsutus*, *Lampides boeticus*, *Spodoptera* spp., *Frankliniella schultzei*, *Thrips palmi,* and *Maruca vitrata* have been intercepted at ports-of-entry by PPQ Officers (USDA. 2005; USDA APHIS PPQ, 2005); this offers some evidence of their ability to survive shipment.

Not detected at port-of-entry

Estimating the risk that pests will not be detected at a port-of-entry involves the consideration of pest size, mobility, and degree of concealment. Depending on the age of infestation, internal feeders have a High probability of escaping detection at a port-of-entry, unless pods are cut open. Internal feeders (*Maruca vitrata, Lampides boeticus, Bactrocera cucurbitae, Spodoptera litura*) are ranked High (3) because of the potential to escape detection at the port-of-entry. These insects will generally not be detected unless fruits are destructively sampled. White and Elson-Haris (1994) stated that fruit flies had a High probability of escaping detection at a port-of-entry, and infested fruit could go unrecognized.

Crytophlebia ombrodelta infestation in various Hawaiian commodities is mitigated by culling and inspection. This is possible because of their large size, and because of their habit to go in and out of the fruit.

Large, conspicuous infestations could lead to the detection of scale insects. Sparser populations of these small insects, thrips, and mites are more difficult to detect, particularly if concealed on the pod, or in packing materials. The external feeders *Aleurodicus dispersus, Dysmicoccus neobrevipes, Maconellicoccus hirsutus, Oligonychus biharensis, Thrips palmi* and *Franklinella schultzii* are ranked Medium (2).

Moved to suitable habitat

Aleurodicus disperses, Bactrocera cucurbitae, Crytophlebia ombrodelta, Dysmicoccus neobrevipes, Maconellicoccus hirsutus Maruca vitrata, Oligonychus biharensis, and *Thrips palmi* are known to have warm temperate to tropical distributions. It is estimated that climates suitable for the pests to establish permanent populations is only a narrow swath of territory in the south and along the west coast of the continental United States. These regions would comprise an estimated 10-12% of the total land area of the country. These species were ranked Medium (2).

Franklinella schultzii and *Spodoptera litura* have High (3) potentials to move to environmentally suitable locations; these species survive in a wide range of climate zones, and are polyphagous.

Lampides boeticus only feed on beans; however, because of the abundance of leguminous plants throughout the continental United States (including wild hosts), the ability of this species to fly long distances, and to survive a wide range of climate zones, contribute to the high likelihood that this pest will move to an environmentally suitable location. *Lampides boeticus* was ranked High (3).

Contact with host material

The fruit fly *Bactrocera cucurbitae* is rated as High (3). Fruit flies have a wide range of host species, found not only in the subtropical and tropical zones, but also in the temperate zones of the United States.

The whitefly, *Aleurodicus dispersus,* is rated High (3). The whitefly is highly polyphagous; natural dispersal can be ensured by flying adults (EPPO, 2004); however, it is pest of tropical and subtropical crops (EPPO, 2004), and tropical and subtropical areas are limited in continental United States.

Mealybugs, *Dysmicoccus neobrevipes* and *Maconellicoccus hirsutus,* have limited powers of dispersal, and lack the ability to quickly locate suitable hosts. They are rated Medium (2).

Thrips, *Franklinella schultzii* and *Thrips palmi,* are rated High (3). These pests have a wide range of host plants, many of which occur in temperate zones. Additionally, these species have already established limited populations in the continental United States, evidence of their ability to find acceptable host material.

The moth, *Spodoptera litura,* has a High (3) rating. This species has a wide host range and climate zone. *Spodoptera litura* is a highly mobile species (CABI, 2003). There are several records indicating that this species has migrated substantial distances; therefore, the potential of coming into contact with host species is High (Saito, 2000).

Lampides boeticus is rated High. Host materials are distributed throughout the United States. This species can survive in a wide range of climates. Similarly, the pod borers, *Crytophlebia ombrodelta* and *Maruca vitrata,* are also rated High (3). Although these species only survive in tropical and subtropical regions, the host materials are distributed throughout the continental United States.

The mite *Oligonychus biharensis* is rated Low (1). Although polyphagous, this species is not very mobile, and its probability of coming into contact with host material is Low. Its host species is limited to tropical and subtropical plants.

Table 6. Risk Rating for Likelihood of Introduction of Cowpea, *Vigna unguiculata*, from Hawaii.

Pest Species	Quantity imported annually	Survive post-harvest treatment	Survive shipment	Not detected at port-of-entry	Moved to a suitable habitat	Contact with host material	Cum. Risk Rating
Aleurodicus dispersus	Low (1)	Medium (2)	High (3)	Medium (2)	Medium (2)	High (3)	**Medium (13)**
Bactrocera cucurbitae	Low (1)	High (3)	High (3)	High (3)	Medium (2)	High (3)	**High (15)**
Crytophlebia ombrodelta	Low (1)	High (2)	High (3)	High (2)	Medium (2)	High (3)	**Medium (13)**
Dysmicoccus neobrevipes	Low (1)	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	**Medium (12)**
Franklinella schultzii	Low (1)	Medium (2)	High (3)	Medium (2)	High (3)	High (3)	**Medium (14)**
Lampides boeticus	Low (1)	High (3)	High (3)	High (3)	High (3)	High (3)	**High (16)**
Maconellicoccus hirsutus	Low (1)	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	**Medium (12)**
Maruca vitrata	Low (1)	High (3)	High (3)	High (3)	Medium (2)	High (3)	**High (15)**
Oligonychus biharensis	Low (1)	Medium (2)	High (3)	Medium (2)	Medium (2)	Low (1)	**Medium (11)**
Spodoptera litura	Low (1)	Medium (2)	High (3)	High (3)	High (3)	High (3)	**High (15)**
Thrips palmi	Low (1)	Medium (2)	High (3)	Medium (2)	Medium (2)	High (3)	**Medium (13)**

2.7 Conclusions

The summation of the values for the Consequences of Introduction and the Likelihood of Introduction yields Pest Risk Potential values (USDA, 2000) (Table 7). This is an estimate of the unmitigated risks associated with this importation.

Table 7. Pest Risk Potential

Pest Species	Consequences of Introduction	Likelihood of Introduction	Pest Risk Potential
Aleurodicus dispersus	High (13)	Medium (13)	**Medium (26)**
Bactrocera cucurbitae	High (14)	High (15)	**High (29)**
Cryptophlebia ombrodelta	High (13)	Medium (13)	**Medium (26)**
Dysmicoccus neobrevipes	High (13)	Medium (12)	**Medium (25)**
Franklinella schultzii	High (13)	Medium (14)	**High (27)**
Lampides boeticus	Medium (12)	High (16)	**High (28)**
Maconellicoccus hirsutus	High (14)	Medium (12)	**Medium (26)**
Maruca vitrata	High (13)	High (15)	**High (28)**
Oligonychus biharensis	Medium (12)	Medium (11)	**Medium (23)**
Spodoptera litura	High (15)	High (16)	**High (31)**
Thrips palmi	High (14)	Medium (13)	**High (27)**

Pests with a Pest Risk Potential value of Low do not require specific mitigation measures, whereas a value within the Medium range indicates that specific phytosanitary measures may be necessary. The PPQ Guidelines state that a High Pest Risk Potential means that specific phytosanitary measures are strongly recommended, and that port-of-entry inspection is not considered sufficient to provide phytosanitary security.

An appropriate risk mitigation option is an irradiation treatment at a dose of 400 Gy (7 CFR §305.31) for all quarantine-significant insect pests; however, no data are available on the tolerance of fresh *Vigna unguiculata* pods to irradiation treatment. Dried seeds of *Vigna unguiculata* tolerate irradiation doses of 100 Gy, based on analyses of nutritional content; at this dose, no unfavorable consequences were observed in protein level, amino acid composition, and levels of vitamins B1, B2, and B6 (Diop *et al*. 1997).

A warm, soapy, water wash, and brushing (T102-c, PPQ Treatment Manual), followed by inspection, would provide the necessary mitigation for the acarine *Oligonichus biharensis*, as well as for the externally feeding thrips, pseudococcids, and aleyrodids.

Culling and inspection for larval infestations of *Cryptophlebia ombrodelta* before irradiation treatment are among mitigation procedures allowing movement of Hawaiian tropical fruit commodities into continental United States (7 CFR §318.13).

Beans, including genus *Vigna*, appear to be tolerant of methyl bromide fumigation. Treatment schedules using methyl bromide for internal feeding insects in bean pods, including *Maruca vitrata,* are specified in T101-k-2 and T101-k-2-1. Methyl bromide treatment schedule for external arthropods on fresh beans, including spider mites, thrips, scale insects and surface-feeding caterpillars, is specified in T104-a-1 (PPQ Treatment Manual).

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Appendix A: Criteria used to determine risk ratings

Consequences of Introduction

<u>Risk Element #1: Climate – Host Interaction</u>
When introduced to new areas, pest can be expected to behave as they do in their native areas if host plants and climates are similar. Ecological zonation and the interactions of pests with their biotic and abiotic environments are considered in this element. Estimates are based on the availability of host material and suitable climate conditions. To rate this Risk Element, the U.S. "Plant Hardiness Zones" created by U.S. Department of Agriculture (USDA ARS, 1990), is used (Figure 1). Due to the availability of both suitable host plants and suitable climate, the pest has the potential to establish a breeding colony:

Low (1): In a single plant hardiness zone.

Medium (2): In two or three plant hardiness zones.

High (3): In four or more plant hardiness zones.

<u>Risk Element #2: Host Range</u>
The risk posed by a plant pest depends on its ability to establish a viable, reproductive population, and its potential for causing plant damage. For arthropods, risk is assumed to be positively correlated with host range. For pathogens, risk is ore complex and is assumed to depend on host range, aggressiveness, virulence and pathogenicity; for simplicity, risk is rated as a function of host range.

Low (1): Pest attacks a single species or multiple species within a single genus.

Medium (2): Pest attacks multiple species within a single plant family.

High (3): Pest attacks multiple species among multiple plant families.

<u>Risk Element #3: Dispersal Potential</u>
A pest may disperse after introduction to a new area. The following items are considered: reproductive patterns of the pest (*e.g.*, voltinism, biotic potential); inherent powers of movement; factors facilitating dispersal, wind, water, presence of vectors, human, *etc.*

Low (1): Pest has neither high reproductive potential nor rapid dispersal capability.

Medium (2): Pest has either high reproductive potential OR the species is capable of rapid dispersal.

High (3): Pest has high biotic potential, *e.g.*, many generations per year, many offspring per reproduction ("r-selected" species), AND evidence exists that the pest is capable of rapid dispersal, *e.g.*, over 10 km/year under its own power; via natural forces, wind, water, vectors, *etc.*, or human-assistance.

<u>Risk Element #4: Economic Impact</u>
Introduced pests are capable of causing a variety of direct and indirect economic impacts. These impacts are divided into three primary categories (other types of impacts may occur): lower yield of the host crop, *e.g.*, by causing plant mortality, or by acting as a disease vector; lower value of the commodity, *e.g.*, by increasing costs of production, lowering market price, or a combination; loss of foreign or domestic markets due to the presence of a new quarantine pest.

Low (1): Pest causes any one or none of the above impacts.

Medium (2): Pest causes any two of the above impacts.

High (3): Pest causes all three of the above impacts.

<u>Risk Element #5: Environmental Impact</u>
The potential of each pest to cause environmental damage (FAO, 1996) proceeds by considering the introduction of the pest as it is expected to cause significant, direct environmental impacts, *e.g.*, ecological disruptions, reduced biodiversity. (1) When used within the context of the National Environmental Policy Act (NEPA) (7CFR §372), significance is qualitative and encompasses the likelihood and severity of an environmental impact; (2) a pest that is expected to have a direct impact on other existing species is listed by federal agencies as endangered or threatened (50CFR §17.11 and §17.12), by infesting/infecting a list plant. If the pest attacks other species within the genus or other genera within the family, and preference/no preference tests have not been conducted with the listed plant and the pest, then the plant is assumed to be a host; (3) the pest is expected to have an indirect impact on the species listed by federal agencies as endangered or threatened by disrupting the sensitive, critical habitats; (4) the introduction of such a pest would stimulate chemical or biological control programs.

Low (1): None of the above would occur. It is assumed that the introduction of a nonindigenous pest will have some environmental impact (by definition, introduction of a nonindigenous species affects biodiversity).

Medium (2): One of the above would occur.

High (3): Two or more of the above would occur.

Likelihood of Introduction

<u>Risk Element #6: Pest Opportunity (Survival and Access to Suitable Habitat and Hosts)</u>

For each pest, consider six sub-elements:

1. **Quantity of commodity imported annually**: The likelihood that an exotic pest willbe introduced depends on the amount of the potentially-infested commodity that isimported. For qualitative pest risk assessments, the amount of commodity imported isestimated in units of standard 40 foot long

shipping containers. In those cases wherethe quantity of a commodity imported is provided in terms of kilograms, pounds,number of items, *etc*., convert the units into terms of 40 foot shipping containers.Score as follows:

Low (1 point): < 10 containers/year

Medium (2 points): 10 - 100 containers/year

High (3points): > 100 containers/year

2. **Survive post-harvest treatment**: For this sub-element, post-harvest treatment refers to any manipulation, handling or specific phytosanitary treatment to which the commodity is subjected. Examples of post-harvest treatments include culling, washing, chemical treatment, cold storage, *etc*. If there is no post-harvest treatment, estimate the likelihood of this sub-element as High.

3. **Survive shipment:** Estimate survival during shipment; assume standard shipping conditions.

4. **Not be detected at the port-of-entry**: Unless specific protocols are in place for special inspection of the commodity in question, assume standard inspection protocols for like commodities. If no inspection is planned, estimate this sub-element as High.

5. **Imported or moved subsequently to an area with an environment suitable for survival:** Consider the geographic location of likely markets and the proportion of the commodity that is likely to move to locations suitable for pest survival. Even if infested commodities enter the country, not all final destinations will have suitable climatic conditions for pest survival.

6. **Come into contact with host material suitable for reproduction:** Even if the final destination of infested commodities are suitable for pest survival, suitable hosts must be available in order for the pest to survive. Consider the complete host range of the pest species.

Rate sub-elements 2-6 as follows:

Low (1 point): < 0.1% (less than one in one thousand)

Medium (2 points): Between 0.1% - 10% (between one in one thousand to one in ten)

High (3 points): > 10% (greater than one in ten)

The events described in sub-elements 2 - 6 should be considered as a series of independent events that must all take place before a pest outbreak can occur, *i.e.*, the estimates for one element should not affect estimates for other elements.

For each pest, sum the six sub-elements to produce a Cumulative Risk Rating for the Likelihood of Introduction. This Cumulative Risk Rating is considered to be an indicator of the likelihood that a particular pest would be introduced. Interpret the Cumulative Risk Rating for the Likelihood of Introduction as follows:

Low: 6 - 9 points

Medium: 10 - 14 points

High: 15 - 18 points