United States Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine

Risk Analysis of the Importation of Moth Orchid, *Phalaenopsis* spp., Plants in Approved Growing Media From Taiwan into the United States

Agency Contacts:

Gary L. Cave, Ph.D. (Risk Assessment)
United States Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Center for Plant Health Science and Technology
Plant Epidemiology and Risk Analysis Laboratory
1017 Main Campus Drive, Suite 1550
Raleigh, NC 27606-5202

William E. Thomas (Risk Management)
United States Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Phytosanitary Issues Management Team
4700 River Road, Unit 140
Riverdale, MD 20737-1236

May 6, 2003

Executive Summary

This pathway-initiated commodity risk assessment examines the risks associated with the proposed importation of moth orchid, *Phalaenopsis* spp., plants (including those with inflorescences and buds) in approved growing media from Taiwan into the United States. The quarantine pests that are likely to follow the pathway are analyzed using the methodology described in the USDA, APHIS, PPQ Guidelines 5.02 which examines pest biology in the context of the Consequences of Introduction and the Likelihood of Introduction and estimates the Baseline Pest Risk Potential.

The quarantine pests likely to follow this importation pathway are: *Acusta* (*Bradybaena*) *tourranensis* (Souleyet) (Mollusca: Bradybaenidae), *Planococcus minor* (Maskell) (Homoptera: Pseudococcidae), *Cylindrosporium phalaenopsidis* Saw. (Fungi Imperfecti, Coelomycetes), *Phomopsis orchidophila* Cash & A. M. Watson (Fungi Imperfecti, Coelomycetes), *Sphaerulina phalaenopsidis* Saw. (Loculoascomycetes, Dothideales), and *Spodoptera litura* (F.) (Lepidoptera: Noctuidae). The Baseline Pest Risk Potential for *Spodoptera litura* is High, and all the other pests have Baseline Pest Risk Potential ratings of Medium. Port of entry inspections, as the sole mitigation measure, for certain propagative materials, may be insufficient to safeguard U.S. agriculture from these pests, and additional phytosanitary measures are considered necessary to mitigate risks.

The fungus, *Colletotrichum phalaenopsidis* was synonymized to *Colletotrichum gloeosporioides* (Redlin, 2002) after the publication of the original risk assessment in 1996. *Colletotrichum gloeosporioides* is widely distributed in the United States (Farr *et al*. 1989), and therefore this organism is no longer of quarantine concern.

The pest risk management section of this document considers the manner in which regulations for the importation of plants in APHIS-approved growing media (7 CFR § 319.37-8) will reduce the risks associated with this importation. The application of additional safeguards will reduce the risk posed by the importation of Moth Orchid, *Phalaenopsis* spp. plants in growing media from Taiwan. The safeguards will effectively remove the pests of concern from the pathway and reduce the risk to a low level, that will be the same level or below that posed by currently permitted bare root importations.

Table of Contents

I. Introduction 1

II. Risk Assessment 1

A. Initiating Event: Proposed Action 1

B. Assessment of Weediness Potential of the Commodity 1

C. Current Status and Pest Interceptions 2

D. Pest Categorization 2

E. Analysis of Quarantine Pests 8

F. Conclusion: Pest Risk Potential 17

III. Risk Management 18

IV. References 27

V. Authors and Reviewers/Contributors 34

I. Introduction

This risk analysis was prepared by the Plant Epidemiology and Risk Analysis Laboratory of the United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Center for Plant Health Science and Technology (USDA, APHIS, PPQ, CPHST, PERAL) to examine the plant pest risks associated with the importation of moth orchid plants, in approved growing media, from Taiwan into the United States. Risk is characterized as high, medium or low, following version 5.02 of the PPQ Guidelines (USDA, 2000) and is linked to the supporting scientific evidence in order to provide clarity.

Regional and international plant protection organizations, such as the 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 both guidance for conducting pest risk assessments (FAO, 1995, 1996, 2001) and the use of biological and phytosanitary terms (FAO, 1999). The terms and the methods used to initiate, conduct and report this assessment are consistent with these international guidelines. This document satisfies the requirements of the three stages of the FAO guidelines (Initiation, Risk Assessment and Risk Management), and is consistent with applicable U.S. regulations, *e.g.* 7 CFR § 319.40-11 and 7 CFR § 319.37-8(g).

II. Risk Assessment

A. Initiating Event: Proposed Action

This commodity-based, pathway-initiated pest risk assessment examines the phytosanitary risks associated with the potential importation, from Taiwan into the United States, of moth orchid plants rooted in APHIS-approved growing media. The importation of propagative material into the United States is regulated under "Subpart-Nursery Stock," 7 CFR § 319.37 through 319-37-14, and a risk analysis was conducted by APHIS in furtherance of its mission under the Plant Protection Act of 2000 (7 U.S.C. §§ 7701-7772).

B. Assessment of the Weediness Potential of Moth Orchid

If the species considered for import poses a risk as a weed pest, then a "pest initiated" risk assessment is conducted. The results of the screening for weed potential for moth orchid (Table 1) did not prompt a pest initiated risk assessment because plants already present in the United States are not reported as weeds.

Table 1: Process for Determining Weediness Potential of Moth Orchid.
Commodity: *Phalaenopsis* Blume (Orchidaceae). A genus of 40-50 cultivated ornamental epiphytes or chasmophytes native to tropical Asia, Philippines, and Malaysia, yielding hothouse orchids. Phase 1: Consider whether the genus is new to or not widely prevalent in the United States (exclude plants grown under USDA permit in approved containment facilities) *Phalaenopsis* is widely cultivated in greenhouses in Florida and other places in the United States. Florida has over 51 growers and shipped over 3 million potted orchids in 2001 (USDA, 2002). Phase 2: Answer Yes or No to the following questions: Is the genus listed in: <u>NO</u> Geographical Atlas of World Weeds (Holm *et al.*, 1979) <u>NO</u> World's Worst Weeds (Holm *et al.*, 1977) <u>NO</u> Report of the Technical Committee to Evaluate Noxious Weeds; Exotic Weeds for Federal Noxious Weed Act (Gunn and Ritchie, 1982) <u>NO</u> Economically Important Foreign Weeds (Reed, 1977) <u>NO</u> Weed Science Society of America list (WSSA, 2002) <u>NO</u> Is there any literature reference indicating weed potential, *e.g.*, AGRICOLA, CAB, Biological Abstracts, AGRIS; search on "*Phalaenopsis*" combined with "weed"). Phase 3: Conclusion: The species is prevalent in the United States and the answer to all of the questions is no, therefore, the commodity does not have weediness potential.

C. Current Status and Pest Interceptions

There are no previous requests from Taiwan for *Phalaenopsis* rooted in APHIS-approved growing media. Bare-root *Phalaenopsis* plants and plants established on coconut fiber, fern trunk, and other approved media are allowed entry from Taiwan into the United States (7 CFR § 319.37). Pests intercepted by APHIS between 1985-2003 at U.S. ports of entry are reported in Table 2 (PPQ, 1998; PPQ, 2003), and discussed in Section E. In 2001, there was one interception of a leaf beetle, *Medythis suturalis* (Coleoptera: Chrysomelidae), but this quarantine pest was likely present as an accidental hitchhiker and is not further analyzed because it is not reported in the scientific literature as a pest of *Phalaenopsis* orchids and operational procedures, such as prohibiting packing at night under lights, can be immediately implemented in order to eliminate its occurrence.

D. Pest Categorization

Pests associated with moth orchids in Taiwan are listed in Table 2. This list identifies: (1) the presence or absence of these pests in the United States, (2) hosts, (3) the generally affected plant part or parts, (4) the quarantine status of the pest with respect to the United States, (5) the likelihood of introduction of the pest into the United States on commercially imported moth orchids, and (6) pertinent citations for the distribution or the biology of the pest. Because of specific characteristics of biology and distribution, many organisms are eliminated from further consideration as sources of phytosanitary risk on moth orchids because they do not satisfy the FAO definition of a quarantine pest.

Table 2. Pests of *Phalaenopsis* spp. orchids in Taiwan.

Pest	Distribution[1]	Hosts	Plant Part Affected	Quarantine Pest	Follow Pathway	References
ARTHROPODA						
ACARI						
Acari sp.	TW	*Brassica, Dracaena, Paeonia,* Rutaceae, Various	Leaf, Stem	Yes	Yes	PPQ, 2003
Tarsonemidae						
Xenotarsonemus sp.	TW	*Capsicum, Clemantis, Cymbidium, Dracaena, Odontoglossum Oncidium, Phalaenopsis, Thuja occidentalis,*	Leaf, Stem	Yes	Yes	PPQ, 2003
Tenuipalpidae						
Brevipalpus sp.	TW	*Actinidia, Chamaedorea,* Orchidaceae, Rutaceae, *Vitis,* Polypahagous	Leaf, Stem	Yes	Yes	PPQ, 2003
Tenuipalpus pacificus Baker	TW,US	Orchidaceae, *Phalaenopsis*	Leaf, Stem	No	Yes	Jeppson *et al.*, 1975; Taiwan, 1996
INSECTA						
Insecta sp.	TW	Various	Flower, Leaf, Soil, Stem	Yes	Yes	PPQ, 2003
COLEOPTERA						
Curculionidae						
Curculionidae sp.	TW	*Cymbidium,* Orchidaceae, Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 1998
COLLEMBOLA						
Sminthuridae						
Sminthuridae sp.	TW	*Brassica, Citrus, Dracaena, Paeonia,* Various	Leaf, Stem	Yes	Yes	PPQ, 2003
DIPTERA						
Diptera sp.	TW	Various	Leaf, Soil, Stem	Yes	Yes	PPQ, 2003
Agromyzidae						
Agromyzidae sp.	TW	*Brassica, Dracaena, Paeonia, Punica,* Rutaceae, Various	Leaf, Stem	Yes	Yes	PPQ, 2003
HOMOPTERA						
Aphididae						
Aphididae sp.	TW	*Dendrobium* Orchidaceae, Polyphagous,	Leaf, Stem	Yes	Yes	PPQ, 1998

Pest	Distribution[1]	Hosts	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Cerataphis sp.	TW	Orchidaceae	Leaf, Stem	Yes	Yes	PPQ, 1998
Cicadellidae						
Cicadellidae sp.	TW	*Brassica*, Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 1998
Coccidae						
Coccidae sp.	TW	*Cymbidium*, Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 1998
Saissetia coffeae (Signoret)	TW,US	*Phalaenopsis*	Leaf, Stem	No	Yes	Hamon and Williams, 1984; Taiwan, 1996
Diaspididae						
Diaspididae sp.	TW	Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 1998
Lepidosaphes chinensis Chamberlin	TW	*Areca catechu*, *Cymbidium*, *Cocos nucifera*, *Combrelum lakka*, *Dracena*, *Licuala*, *Litsea cubeba*, *Loranthus*, *Maxillaria*, *Michelia pandanas*, *Rhaphis excelsa*, *Schomburgki*	Leaf, Stem	Yes	Yes	Nakahara, 1982; PPQ, 1998
Parlatoria sp.	TW	*Dendrobium*, Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 1998
Parlatoria proteus (Curtis)	TW,US	Arecaceae, Orchidaceae, Polyphagous	Leaf, Stem	No	Yes	Nakahara, 1982; Taiwan, 1996
Miridae						
Miridae sp.	TW	*Oncidium*, Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 1998
Pseudococcidae						
Planococcus minor (Maskell)	TW	*Phalaenopsis*, Polyphagous	Flower, Leaf, Stem	Yes	Yes	Cox, 1989; PPQ, 1998; Tu *et al.*, 1988; Tandon and Verghese, 1987; Williams, 1982; Williams and Granara de Willink, 1992
Pseudococcidae sp.	TW	*Phalaenopsis*, Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 1998
Pseudococcus sp.	TW	Orchidaceae, Rosaceae, Rutaceae, Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 2003
Pseudococcus longispinus (Targioni Tozzetti)	TW,US	*Phalaenopsis*, Polyphagous	Leaf, Stem	No	Yes	McKenzie, 1967; Taiwan, 1996
HYMENOPTERA						
Formicidae						

Pest	Distribution[1]	Hosts	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Crematogaster sp.	TW	*Eucalyptus, Hemileuca oliviae, Mangifera indica, Pinus, Quercus suber*, Various	Flower, Leaf, Stem	Yes	Yes	PPQ, 2003
LEPIDOPTERA						
Lymantriidae						
Lymantriidae sp.	TW	*Dendrobium*, Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 1998
Noctuidae						
Noctuidae sp.	TW	*Oncidium*, Orchidaceae, Polyphagous	Leaf, Soil, Stem	Yes	Yes	PPQ, 1998
Spodoptera sp.	TW	*Brassia*, Polyphagous	Leaf, Soil, Stem	Yes	Yes	PPQ, 1998
Spodoptera litura (F.)	TW	*Phalaenopsis*, Polyphagous	Leaf, Soil, Stem	Yes	Yes	Anon, 1982; Taiwan, 1996; Smith *et al.*, 1992; Matsuura and Naito, 1992a, b
Plutellidae						
Plutellidae sp.	TW	Orchidaceae	Leaf, Stem	Yes	Yes	PPQ, 1998
Tortricidae						
Tortricidae sp.	TW	Orchidaceae, Polyphagous	Leaf, Stem	Yes	Yes	PPQ, 1998
ORTHOPTERA						
Tettigoniidae						
Tettigoniidae sp.	TW	Orchidaceae, *Phalaenopsis*	Leaf, Stem	Yes	Yes	PPQ, 1998
THYSANOPTERA						
Phlaeothripidae						
Phlaeothripidae sp.	TW	Orchidaceae	Flower, Leaf, Stem	Yes	Yes	PPQ, 1998
Thripidae						
Dichromothrips sp.	TW	Polyphagous	Flower, Leaf, Stem	Yes	Yes	PPQ, 1998
Frankliniella intonsa (Trybom)	TW	*Abelmoschus, Asparagus, Avena, Glycine, Lycopersicon, Medicago, Phaseolus, Prunus*, Orchidaceae, *Trifolium*	Flower, Leaf, Stem	Yes	Yes	Chang, 1987; Chen and Chan, 1987; Chieu *et al.*, 1991; PPQ, 1998; Tang, 1976
Frankliniella schultzei (Trybom)	TW	*Dendrobium*, Polyphagous	Flower, Leaf, Stem	Yes	Yes	PPQ, 1998; Wang, 1987
Thripidae, sp.	TW	*Dendrobium*, Orchidaceae, Polyphagous	Flower, Leaf, Stem	Yes	Yes	PPQ, 1998

Pest	Distribution[1]	Hosts	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Thrips hawaiiensis (Morgan)	TW,US	*Phalaenopsis*, Polyphagous	Flower, Leaf, Stem	No	Yes	Taiwan, 1996
Thrips palmi Karny	TW, US (FL, HI)	*Cymbidium*, *Dendrobium*, Orchidaceae, Polyphagous	Flower, Leaf, Stem	Yes	Yes	Smith *et al.*, 1992; PPQ, 1998
MOLLUSCA						
Bradybaenidae						
Acusta (Bradybaena) tourannensis (Souleyet)	TW	*Acacia confusa*, *Adenanthera microsperma*, *Albizzia lebbeck*, *Chrysalidocarpus lutescens*, *Cocos nucifera*, *Morus alba*, *Phalaenopsis*	Flower, Leaf, Soil, Stem	Yes	Yes	Lai, 1984; Taiwan, 1996; Wu, 1982
Bradybaena sp.	TW	*Phalaenopsis*, Polyphagous	Flower, Leaf, Soil, Stem	Yes	Yes	PPQ, 1998
Succinea sp.	TW	*Aglaonema*, *Aranda*, *Aster*, *Codiaeum*, *Cordyline*, *Dracena*, *Eryngium*, *Heliconia*, *Musa*, Orchidaceae, *Schefflera*, *Vanda*	Leaf, Soil, Stem	Yes	Yes	PPQ, 2003
Vaginulus alte Ferrussae	TW,US	*Phalaenopsis*	Flower, Leaf, Soil, Stem	No	Yes	Taiwan, 1996
BACTERIA						
Acidovorax cattleya (Pavarino) Willems *et al.* (=*Pseudomonas cattleyae* (Pavarino) Savulescu) (Pseudomonadaceae)	TW, US	*Phalaenopsis*, Orchidaceae	Leaf, Stem	No	Yes	Bradbury, 1986; Taiwan, 1996; Willems *et al.*, 1992
Erwinia carotovora subsp. *carotovora* (Jones) Bergey *et al.* (Enterobacteriaceae)	TW, US	*Phalaenopsis*, Various	Leaf, Stem	No	Yes	Anon., 1979; Bradbury, 1986; Pirone, 1978
Erwinia chrysanthemi pv. *zeae* (Sabat) Victoria, Arboleda & Munoz (Enterobacteriaceae)	TW, US	*Phalaenopsis*, Various	Leaf, Stem	No	Yes	Bradbury, 1986; Taiwan, 1996
Erwinia cyperpedii (Hori) Bergey *et al.* (Enterobacteriaceae)	TW, US (CA, FL)	*Carica*, *Phalaenopsis*, Orchidaceae	Leaf, Stem	No	Yes	Bradbury, 1986
FUNGI						

Pest	Distribution[1]	Hosts	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Botrytis cinerea Pers.:Fr. (Fungi Imperfecti, Hyphomycetes)	TW, US	*Phalaenopsis,* Various	Leaf, Stem	No	Yes	Farr *et al*., 1989; Taiwan, 1996
Capnodium sp. (Loculoascomycetes, Dothideales)	TW	*Phalaenopsis,* Various	Leaf, Stem	Yes	Yes	Taiwan, 1996
Cercospora sp. (Fungi Imperfecti, Hyphomycetes)	TW	*Phalaenopsis*, Various	Leaf, Stem	Yes	Yes	PPQ, 1998
Colletotrichum phalaenopsidis Saw. (=*Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. in Penz.) (Fungi Imperfecti, Coelomycetes)	TW, US	*Phalaenopsis,* Various	Leaf, Stem	No	Yes	Anon., 1979; Farr *et al*., 1987; Redlin, 2002; Taiwan, 1996
Cylindrosporium phalaenopsidis Saw. (Fungi Imperfecti, Coelomycetes)	TW	*Phalaenopsis*	Leaf, Stem	Yes	Yes	Anon., 1979
Fusarium sp. (Fungi Imperfecti, Hyphomycetes)	TW	*Capsicum, Musa,* Orchidaceae, Rosaceae, Rutaceae, Solanaceae, Various	Leaf, Stem	Yes	Yes	PPQ, 2003
Fusicoccum sp. (Fungi Imperfecti, Coelomycetes)	TW	*Leucacendron,* Orchidaceae, *Pittosporium, Protea,* Rutaceae, Various	Leaf, Stem	Yes	Yes	PPQ, 2003
Phaeosphaeria sp. (Loculoascomycetes, Dothideales)	TW	*Chamaedorea, Dracena, Heliconia,* Orchidaceae, *Oryza, Viburnum,* Various	Leaf	Yes	Yes	PPQ, 2003
Phomopsis orchidophila Cash & A.M. Watson (Fungi Imperfecti, Coelomycetes)	TW	*Phalaenopsis* Orchidaceae	Leaf	Yes	Yes	Cash and Watson, 1955; PPQ 1998, 2003
Phytophthora nicotianae Breda de Haan var. *parasitica* (Dastur) G. M. Waterhouse (=*Phytophthora parasitica* Dastur) (Oomycetes, Peronosporales)	TW, US	*Phalaenopsis,* Various	Leaf, Stem	No	Yes	Farr *et al*., 1989; Taiwan, 1996
Pythium sp. (Oomycetes, Peronosporales)	TW	*Phalaenopsis,* Various	Leaf, Stem	Yes	Yes	Taiwan, 1996

Pest	Distribution[1]	Hosts	Plant Part Affected	Quarantine Pest	Follow Pathway	References
Sclerotium rolfsii Sacc. (Fungi Imperfecti, Agonomycetes)	TW, US	*Phalaenopsis*, Various	Leaf, Stem	No	Yes	Farr *et al*., 1989; Taiwan, 1996
Sphaerulina phalaenopsidis Saw. (Loculoascomycetes, Dothideales)	TW	*Phalaenopsis*	Leaf, Stem	Yes	Yes	Anon., 1979; Sawada, 1959
VIRUSES						
Cymbidium mosaic potex virus	TW, US	*Phalaenopsis*	Leaf, Stem	No	Yes	Brunt *et al*., 1990; Pirone, 1978; Smith *et al*., 1988
Cucumber mosaic virus	TW, US	*Phalaenopsis*	Leaf, Stem	No	Yes	Zettler *et al*., 1990
Odontoglossum ringspot virus	TW, US	*Phalaenopsis*	Leaf, Stem	No	Yes	Brunt *et al*., 1990

[1]Distribution: TW= Taiwan, US= United States, CA=California, FL= Florida, HI= Hawaii

E. Analysis of Quarantine Pests

The undesirable consequences that may occur from the introduction of quarantine pests are assessed in this section. For each quarantine pest, the potential consequences of introduction are rated using five Risk Elements (REs). These REs (Climate-Host Interaction, Host Range, Dispersal Potential, Economic Impact and Environmental Impact) reflect the biology, host range and climatic/geographic distribution of each pest and are supported by published biological information. For each RE, pests are assigned a rating of Low (1 point), Medium (2 points) or High (3 points). Cumulative risk values are then calculated by a summation of the ratings. The following scale is used to interpret this total: Low (5-8 points) Medium (9-12 points) and High (13-15 points) and are summarized in Table 4. The ratings were determined using the criteria in the risk assessment Guidelines, Version 5.02 (USDA, 2000).

Sources of uncertainty in this analysis stem from the quality of the biological information which includes increased uncertainty whenever biological information is lacking on the regional flora and fauna (Gallegos and Bonano, 1993), and the inherent biological variation within a population of organisms (Morgan and Henrion, 1990). In order to address this uncertainly, only the quarantine pests that can reasonably be expected to follow the pathway, *i.e.*, be included in commercial shipments of *Phalaenopsis* plants are further analyzed. Most of the pests in Table 2 identified only to the order, family or generic level are associated with *Phalaenopsis* only through interceptions of these pests by PPQ officers from cargo, passenger baggage or mail. They could not be identified to species because the intercepted life stage can not be identified to species (*e.g.*, scale insects other than adult females). If identified, these pests may or may not belong to quarantine pest species. These intercepted pests might also represent single instances of hitchhiker pests. The intercepted pests identified only to higher taxa may actually belong to a nonquarantine species already addressed in the document under a species epithet (*e.g.*, *Pseudococcus sp.*= *Pseudococcus longispinus*). The biological hazards of organisms identified only to the order, family or generic levels are not assessed, but if pests identified only to higher taxa are intercepted in the future, reevaluations of their risk may occur at that time. In this risk assessment, this applies to the following taxa: Acari, Agromyzidae, Aphididae, *Brevipalpus* sp., *Cerataphis* sp., Cicadellidae, Coccidae, *Crematogaster* sp., Curculionidae, Diaspididae, *Dichromothrips* sp., Diptera, Lymantriidae, Miridae, Noctuidae, *Parlatoria* sp., Phlaeothripidae, Plutellidae, Pseudococcidae, *Pseudococcus* sp., Smithuridae, *Spodoptera* sp., Tettigoniidae, Thripidae, Tortricidae, *Xenotarsonemus* sp., *Succinea* sp., *Capnodium* sp., *Cercospora* sp., *Fusarium* sp., *Fusicoccum* sp., *Phaeosphaeria* sp., and *Pythium* sp. Because of this uncertainty about species identifications, quarantine action will be required if any of these organisms are intercepted during port of entry inspections by PPQ Officers.

Generally, only the biological hazards of organisms identified to the species level are assessed because often there are many species within a genus, and it is reasonable to assume that the biology of congenerics are similar. Lack of species identification may indicate the limits of the current taxonomic knowledge or the life stage or the quality of the specimen submitted for identification. In cases where only genus-level identification is available but other evidence indicates that pest species in that genus occur in the immediate vicinity and in association with the commodity, it may be assumed (based on the scientific evidence) that such pest species may be present. By necessity, pest risk assessments focus on the organisms for which biological information is available. Development of detailed assessments for known pests that inhabit a variety of ecological niches, such as the surfaces or interiors of fruit, stems or roots, allow effective mitigation measures to eliminate the known organisms as well as similar but incompletely identified organisms that inhabit the same niche. In addition, quarantine species may be present in those groups identified only to the genus level. Should these incompletely identified species be intercepted by PPQ Officers during port of entry inspection, quarantine action will be required.

Other plant pests listed in Table 2 may be potentially detrimental to the agricultural systems of the United States; however, they were not subjected to further analysis for a variety of reasons. First, the pest's primary association may be with plant parts other than the commodity. Secondly, the pests may not be associated with the commodity during transport or processing because of their inherent mobility and/or instinct to avoid light, or human activity. Thirdly, sterile insect stages can be transported in a shipment but are unable to establish viable populations upon entry. Lastly, packing procedures at the country of origin may cause contamination by organisms not normally associated with *Phalaenopsis* orchids. Should any of these biological contaminants be intercepted during inspection by PPQ Officers, quarantine action will be required (PPQ, 2003) and the packing procedures will be modified in order to eliminate the presence of these organisms. In addition, there are instances in Table 2, *e.g.*, *Dichromothrips* sp., *Frankliniella intonsa* (Trybom) and *Lepidosaphes chinensis* Chamberlin, where quarantine pests are listed as either pests of specific genera of orchids other than *Phalaenopsis* or non-specifically, as pests of Orchidaceae. In those cases, the likelihood and consequences of introduction into the United States were not analyzed because no specific host linkages to *Phalaenopsis* could be found in the scientific literature.

The fungus, *Colletotrichum phalaenopsidis* was synonymized with *C. gloeosporioides* (Penz.) (Penz. & Sacc. in Penz.) (Redlin, 2002) after the publication of the original risk assessment in 1996. *Colletotrichum gloeosporioides* is widely distributed in the United States (Farr *et al*. 1989), and therefore is no longer of phytosanitary concern.

Table 3: Quarantine Pests Likely to Follow Pathway
Arthropods *Planococcus minor* *Spodoptera litura* **Mollusks** *Acusta* (= *Bradybaena*) *tourranensis* and *Bradybaena* sp.[1] **Fungi** *Cylindrosporium phalaenopsidis* Saw. [Fungi Imperfecti, Coelomycetes] *Phomopsis orchidophila* Cash & A.M. Watson [Fungi Imperfecti, Coelomycetes] *Sphaerulina phalaenopsidis* Saw. [Loculoascomycetes, Dothideales]

[1]For purposes of this analysis, *Acusta* (= *Bradybaena*) *tourranensis* and *Bradybaena* sp. will be analyzed together.

1. Consequences of Introduction

Risk Element 1: Climate-Host Interaction

The subtropical and tropical orchid-growing areas of Taiwan correspond to USDA Plant Hardiness Zone 11 (average annual minimum temperature, 40EF (ARS, 1960). Zone 11 is relevant to the southern part of Florida Hawaii, Guam, American Samoa, Northern Mariana Islands, U.S. Virgin Islands, Federated States of Micronesia, and Puerto Rico (National Climatic Data Center, 2000). It is unlikely that pests associated with plants grown, either indoors or in a greenhouse, in Plant Hardiness Zones other than Zone 11, will be affected by the outdoor weather in that area. This risk assessment assumes that those pests will be unable to establish or spread in the out-of-doors environment.

The mollusk, *A. tourranensis* has a tropical Asian distribution (Lai, 1984) that corresponds to no more than three climatic zones in the United States (ARS, 1960). The mealybug, *Planococcus minor,* occurs in the Neotropical, Oriental, Austro-oriental, and Malagasian regions represented by no more than three subtropical plant hardiness zones in the Unites States (Cox, 1989). The risk rating for the Climate-Host Interaction for these pests is Medium (2).

In contrast, *Spodoptera litura* occurs over a wide range of climates including Australasia and Asia (CIE, 1993; Pogue, 2002). It is likely to establish in four or more Plant Hardiness Zones in the United States (ARS, 1960); therefore a risk rating of High (3) is warranted.

The geographical distribution of *Phomopsis orchidophila* includes Taiwan, South America, Mexico, Guatemala, Puerto Rico, India, Australia and the Pacific Islands (Uecker, 1988). The climatic ranges for the other pathogens are assumed to be similar. While orchids may be grown outdoors in the southern tier of the United States, generally, they are grown indoors and/or in temperature controlled production facilities (Hartmann and Kester, 1959). The risk rating for the Climate-Host Interaction for these pests is Low (1).

Risk Element 2: Host Range

More than 10 families of plants are listed as hosts for the mollusk, *A. tourranensis*, including herbaceous and tree species (Lai, 1984). The host range of the mealybug, *P. minor*, includes more than 30 species of plants in over ten families (Cox, 1989). The host range for *S. litura* includes plants in the families Cruciferae, Rutaceae, and Fabaceae (Zhang, 1994). The risk rating for the Host Range for each of these pests is High (3).

In the original risk assessment, the host range for the pathogens *Cylindrosporium phalaenopsidis* and *Sphaerulina phalaenopsidis* was assumed to be only *Phalaenopsis*, and there is no evidence to the contrary as of this date (USDA, 1997). The host range for *P. orchidophila* includes only species of *Catasetum*, *Cattleya, Coelogyne*, *Cymbidium* and *Phalaenopsis* (Uecker, 1988). There are approximately 109 species of *Phomopsis* present in the United States, and only three of them are reported to infect more than four different plant host genera (Farr *et al*., 1989). Assuming that *P. orchidophila* is a valid species, it is unlikely that this is a new generalist because reports of it infecting more plants would be seen in the literature. For all of these pathogens, the risk rating for the Host Range is Low (1).

Risk Element 3: Dispersal Potential

Mollusca, a class of animals that includes snails and slugs, live in the soil and under debris. Although the adults may be large and easily detected, the eggs are small. Snails and slugs may chew irregular holes with smooth edges in succulent foliage or fruit, and some can clip succulent plant parts (Ohlendorf, 1999). These pests feed on foliage, flowers and fruit from various plant species, especially in greenhouses (Godan, 1983). The adults of the mollusk, *A. tourranensis*, are large and likely to be dislodged from plants before transport (Godan, 1993; Ohlendorf, 1999). Adults and juveniles move slowly from one site to another, and the reproductive cycle is long and few eggs are produced (Lai, 1984). This pest is reported only in southern Taiwan, and has not spread to other areas of Asia, indicating limited dispersal capabilities (Wu, 1982). The Dispersal Potential for this pest is rated Low (1).

The generalized life history of mealybugs (Pseudococcidae) indicates that crawlers readily spread among closely placed plants (Cox, 1989; McKenzie, 1967; Williams and Granara de Willink, 1992). Ovipositing females are sedentary, and can lay up to 500 eggs per event; there can be as many as 10 generations per year on a host (Cox, 1989; McKenzie, 1967; Williams and Granara de Willink, 1992). The primary mode of long distance dispersal is through commercial movement of plants (CABI, 1999). Although distributed in the U.S. Virgin Islands (ScaleNet, 2002), there are no interceptions of *P. minor* on *Phalaenopsis* species (PPQ, 2003). For these reasons, the risk rating for the Dispersal Potential of this mealybug is Medium (2).

Female *S. litura* oviposit in clusters of several hundred eggs, fecundity ranges from 2,000-2,600 eggs per female, there may be up to 12 generations per year, moths can fly up to 1.5 km per night and eggs and larvae may be spread long distances through commerce (Anon., 1982; CABI, 1999; CIE, 1993; Matsuura and Naito, 1992a; 1992b; Pogue, 2002). For these reasons, the risk rating for the Dispersal Potential of *S. litura* is High (3).

The fungal pathogens, *Cylindrosporium phalaenopsidis* and *Phomopsis orchidophila*, are in genera that produce spores that are splashed by irrigation or rain onto nearby hosts (Agrios, 1997; Pirone, 1978). These spores also may be carried by insects, animals, and humans moving among plants (Agrios, 1997; Pirone, 1978). *Sphaerulina phalaenopsidis* is in a genus that produces air dispersed spores that are not likely to be widely dispersed over long distances (Agrios, 1997). For these reasons, the risk rating for the Dispersal Potential for all the pathogens is Medium (2).

Risk Element 4: Economic Impact

Mollusk feeding reduces the visual quality of the plant, the available photosynthetic surface area, and some clip succulent plant parts (Godan, 1983; Ohlendorf, 1999). The introduction of the mollusk *Bradybaena similaris* (Ferrussac) into Louisiana and other states from tropical China necessitated control treatments for this occasional citrus and garden pest (Aguirre and Poss, 2000). It is anticipated that if *A. tourranensis* is introduced into a new area, there will be a need for similar control measures. The mealybug, *Planococcus minor,* may vector a virus (Cox, 1989). Additionally, large populations can rapidly develop on a host, and decrease plant quality through the accumulation of unsightly sooty molds and plant wilting (Cox, 1989; McKenzie, 1967; Williams and Granara de Willink, 1992). For these reasons, the Economic Impact rating for these pests is Medium (2).

Spodoptera litura causes major damage to tobacco, cotton, chilies, cabbage, and other crops (Anon., 1982; CABI, 1999; CIE, 1993; Matsuura and Naito, 1992a; 1992b; Pogue, 2002). Where it is present, it is responsible for heavy quality and yield loss and qualifies as a key pest (Smith, *et al*., 1997). A density of 1.5 larvae per plant reduced yield of greenhouse peppers by 10% (CABI, 1999). In tomatoes, larvae bore into fruit and reduce quality significantly (CABI, 1999; Smith, *et al*., 1997). For these reasons, the Economic Impact rating for this pest is High (3).

The fungal pathogens, *Cylindrosporium phalaenopsidis*, *Phomopsis orchidophila* and *Sphaerulina phalaenopsidis*, are in genera that infect leaves (Agrios, 1997; Pirone, 1978). Most leaf-spot causing pathogens reduce visual quality and decrease the value of ornamental crops in addition to reducing the available photosynthetic area and reducing plant vigor (Agrios, 1997; Pirone, 1978). These losses reduce the market value of the plants (Agrios, 1997). The risk rating for the Economic Impact for these pathogens is Medium (2).

Risk Element 5: Environmental Impact

There is no evidence that any Endangered, Threatened or Candidate species are hosts of quarantine pests. The two insect pests, *Planococcus minor* and *Spodoptera litura*, however, have hosts that are congeneric with USFWS listed species (Table 4) (USFWS, 2001). This should not be interpreted to mean that any listed species can be hosts for these pests. Rather, this Table should be interpreted as an extrapolation from scientifically demonstrated host ranges and represents a possible, not a probable potential for harm to the environmental resources in the United States. These possible impacts in combination with the direct and indirect effects of these pests on hosts warrant a risk rating for Environmental Impact of Medium (2) for *Planococcus minor* and *Spodoptera litura*.

Table 4. Listed species that potential pests may adversely impact. (Each listed plant is congeneric with a host of a quarantine pest likely to follow the pathway in an unmitigated importation of plants.

Listed species	Status[1]	Range	Pest with a host in the same genus as the listed species
Amaranthus brownii *A. pumilus*	E T	HI DE, MA, MD, NC, NJ, NY, RI, SC	*Planococcus minor*
Cucurbita okeechobeensis ssp. *Okeechobeensis*	E	FL	
Cyperus trachysanthos	E	HI	
Euphorbia haeleeleana *E. telephioides*	E T	HI FL	
Helianthus eggertii *H. paradoxus* *H. schweinitzii* *H. verticillatus*	T T E C	AL, KY, TN NM, TX NC, SC AL, GA, TN	
Justicia cooleyi	E	FL	
Manihot walkerae	E	TX, MX	
Rhus michauxii	E	GA, NC, SC, VA	
Solanum drymophilum *S. incompletum* *S. nelsonii* *S. sandwicense*	E E C E	PR HI HI HI	
Verbena californica	T	CA	
Vigna o-wahuensis	HI	E	
Ziziphus celata	E	FL	
Apios priceana	T	AL, IL, KY, MS, TN	*Spodoptera litura*
Allium munzii	E	CA	
Linum arenicola *L. carteri carteri*	C C	FL FL	
Manihot walkerae	E	TX, MX	
Trifolium ameonum *T. stoloniferum* *T. trichocalyx*	E E E	CA AR, IL, IN, KS, KY, MO, OH, WV CA	
Vigna o-wahuensis	E	HI	

[1] E = Endangered species; T = Threatened species; C = Candidate species

The following host genera for *Planococcus minor* did not correspond to any genera listed as threatened, endangered, proposed or candidate: *Abutilon, Acacia, Acalypha, Adenanthera, Aglaonema, Aleurites, Alocasia, Alphitonia, Alpinia, Anacardium, Ananas, Annona, Antidesma, Aphelandra, Apium, Arachis, Aralia, Araujia, Areca, Artocarpus, Asparagus, Balaka, Barringtonia, Bauhinia, Bidens, Bischofia, Boehmeria, Borreria, Brassica, Broussonetia, Brunfelsia, Caesia, Cajanus, Calliandra, Calophyllum, Camellia, Cananga, Capsicum, Cassia, Castilla, Casuarina, Centrosema, Chrysalidocarpus, Cichorium, Citrullus, Clerodendrum, Cocos, Codiaeum, Coffea, Coleus, Commelina, Cordia, Corynocarpus, Crinum, Croton, Cryptosperma,* *Dahlia, Datura, Dendrobium, Dieffenbachia, Dioscorea, Elettaria, Emilia, Epimeredi, Epipremnum, Erythrina, Eucalyptus, Eugenia, Evodia, Excoecaria, Fagraea, Ficus, Flemingia, Gardenia, Gladiolus, Gliricidia, Glochidion, Glycine, Gossypium, Graptophyllum, Guettarda, Harrisia, Hedychium, Heliconia, Hibiscus, Howeia, Hoya, Hyptis, Impatiens, Inocarpus, Ipomoea, Ixora, Jatropha, Kleinhovia, Lagerstroemia, Leucaena, Leucosyke, Ludwigia, Lumnitzera, Lycopersicon, Macadamia, Macaranga, Mallotus, Mangifera, Manilkara, Maranta, Merremia, Michelia, Mikania, Mimosa, Morinda, Morus, Mucuna, Musa, Myristica, Nicolaia, Ocimum, Odontonema, Pachystachys, Pandanus, Passiflora, Pavonia, Pemphis, Persea, Phaseolus, Philodendron, Phyllanthus, Piper, Pipturus, Pistia, Pluchea, Plumeria, Polyscias, Pometia, Premna, Procris, Psidium, Pyrus, Randia, Raphanus, Rhaphidophora, Ricinus, Rosa, Russelia, Saccharum, Schefflera, Sechium, Spondias, Stachytarpheta, Synedrella, Tagetes, Tectona, Terminalia, Theobroma, Tithonia, Tournefortia, Tradescantia, Triumfetta, Vitex, Vitis, Wedelia, Wisteria, Xanthosoma, Zea, Zingiber, Zinnia.*

The following host genera for *Spodoptera* sp. did not correspond to any genera listed as threatened, endangered, proposed or candidate: *Abelmoshus, Alternanthera, Ananas, Apium, Arachis, Asparagus, Bacop, Beta, Brachiaria, Brassica, Camellia, Capsicum, Castilla, Chrysanthemum, Cicer, Citrus, Coccinia, Colocasia, Corchorus, Cyamopsis, Cynara, Cynodon, Derris, Digitaria, Echinochloa, Eichornia, Eleusine, Elymus, Eremochloa, Erythxylym, Fimbristylis, Fragaria, Gladiolus, Glycine, Gossypium, Hordeum, Ipomoea, Isachne, Kumara, Lablab, Leptochloa, Leucaena, Lilium, Luffa, Medicago, Morus, Musa, Nicotiana, Oryza, Paspalum, Pennisetum, Phaseolus, Ricinus, Rosa, Saccharum, Sesbania, Sorghum, Spinacia, Stenotaphrum, Theobroma, Triticum, Ulmus, Vitis, Zea, Zoysia.* Because of its wide host and climate range and high capacities for dispersal, we estimate introduction of *Spodoptera litura* would lead to significant ecological impact and trigger chemical or biological control programs. This element is rated as high for *Spodoptera litura*.

There are no populations of the mollusk, *Acusta tourannensis*, established from the importations of bare-root *Phalaenopsis* plants into the United States to date, and it is rarely intercepted on these plants (PPQ, 2003). Nevertheless, snails are spread in commerce, and due to their hermaphroditism, one snail can start a population (Godan, 1983). If this pest established, it would be likely to disrupt unmanaged ecosystems in the subtropical areas of Hawaii, Florida, and other climatically similar areas. The Environmental Impact risk rating for this mollusk is Medium (2).

In the earlier version of this risk assessment document (USDA, 1997), the host range for the pathogens *Cylindrosporium phalaenopsidis* and *Sphaerulina phalaenopsidis* was assumed to be only *Phalaenopsis*, and there is no evidence to the contrary as of this date. It is not reasonable to assume that these fungi have unlimited host ranges, based on Flor's Gene for Gene Theory which says that host specificity is the norm based on the evolutionary genetic interactions between hosts and pathogens (Agrios, 1997). It is unreasonable to assume that they will infect host plants *ad infinitum*. For these reasons, the Environmental Impact rating for these pathogens is Low (1).

Table 5: Summary of the Risk Ratings and the Value of the Consequences of Introduction						
Pest	**Climate/Host Interaction**	**Host Range**	**Dispersal Potential**	**Economic Impact**	**Environ-mental Impact**	**Consequences of Introduction Value**
Acusta tourranensis	Medium (2)	High (3)	Low (1)	Medium (2)	Medium (2)	Medium (10)
Planococcus minor	Medium (2)	High (3)	Medium (2)	Medium (2)	Medium (2)	Medium (11)
Spodoptera litura	High (3)	High (3)	High (3)	High (3)	High (3)	High (15)
Cylindrosporium phalaenopsidis	Low (1)	Low (1)	Medium (2)	Medium (2)	Low (1)	Low (7)
Phomopsis orchidophila	Low (1)	Low (1)	Medium (2)	Medium (2)	Low (1)	Low (7)
Sphaerulina phalaenopsidis	Low (1)	Low (1)	Medium (2)	Medium (2)	Low (1)	Low (7)

2. Likelihood of Introduction

The likelihood of introduction for a pest is rated relative to six factors which includes the quantity to be imported (USDA, 1995). As per the Guidelines v.5.02, the value for the Likelihood of Introduction is the sum of the ratings for the Quantity Imported Annually and the Summary of the Risk Ratings for the Likelihood of Introduction (Table 6). The following scale is used to interpret this total: Low is 6-9 points, Medium is 10-14 points and High is 15-18 points.

Risk Element 6, subelement 1: Quantity of commodity imported annually

The rating for the Quantity Imported Annually is based on the amount reported by the country of proposed export converted into standard units of 40-foot long shipping containers. Permission to import into the United States is likely to be linked with an increase in production in the future and subsequent increases in the volumes of imports. No more than 10 containers per year have ever been exported or are expected to be exported from Taiwan into the United States.

The assessment next considers ratings in five additional areas. These ratings are based on the biological features exhibited by the pest's interaction with the commodity, and represent a series of independent events that must all take place before a pest outbreak can occur. The five areas consider the availability of postharvest treatments, whether the pest can survive through the interval of normal shipping procedures, whether the pest can be detected during a port of entry inspection, the likelihood that the pest will be imported or subsequently moved into a suitable environment, and the likelihood that the pest will come into contact with suitable hosts.

Risk Element 6, subelement 2: Availability of Post-harvest Treatments

There are no specific postharvest treatments proposed to control, reduce or eliminate any of the pest species, so this element is rated High (3) for all the pests.

Risk Element 6, subelement 3: Survive Shipment

The plants are expected to be shipped at moderate temperatures and humidity which is unlikely to adversely affect any of the quarantine pest populations that are present during shipment. Larval stages of *Spodoptera* sp. routinely survive shipment, and *Planococcus minor* is often intercepted (PPQ, 2003). The conditions required for plant survival during shipment will not inhibit the growth of any fungi that are likely to follow the pathway. For these reasons, this element is rated High (3) for all the pests.

Risk Element 6, subelement 4: Not Detected at the Port of Entry

Standard inspection techniques are highly likely to detect larger mature and juvenile forms of the mollusk, *A. tourranensis*, present on plants (Robinson, 2002). Although small eggs in soil are highly likely to escape detection, plants produced in APHIS-approved growing media under pest-exclusionary conditions are expected to be free of mollusk eggs. This element is rated Low (1) for this pest.

Standard visual inspection techniques are not likely to detect microscopic crawler stages of the mealybug, *Planococcus minor* (CABI, 1999). In contrast, the adults, associated sooty mold, and wilting are readily detected (CABI, 1999; Cox, 1989; McKenzie, 1967; Williams and Granara de Willink, 1992). This element is rated Medium (2) for this pest.

The larvae of *Spodoptera litura* can be up to 45 mm in length and are on plant surfaces where they are readily detected (Anon., 1982; CABI, 1999; CIE, 1993; Matsuura and Naito, 1992a; b; Pogue, 2002; Smith, *et al*., 1997). Eggs hidden between leaves, in media, or within flowers are more difficult to detect (Pogue, 2002). This element is rated Medium (2) for this pest.

The pathogens, *C. phalaenopsidis*, *P. orchidophila* and *S. phalaenopsidis,* infect leaves causing leafspots (Agrios, 1997; Pirone, 1978) that are easily detected by trained inspectors. Latent infections are unlikely to be detected (Agrios, 1997; Pirone, 1978). For these reasons, this element is rated Medium (2) for these pests.

Risk Element 6, subelement 5: Moved to a Suitable Habitat

Mollusks and mealybugs shipped to temperate United States ports in winter, spring, or fall are not likely to find suitable outdoor habitats, but if quickly transported into warm, indoor sites (such as greenhouses or shops) the pests may proliferate (CABI, 1999; Cox, 1989; Godan, 1993; Lai, 1984; McKenzie, 1967; Ohlendorf, 1999; Williams and Granara de Willink, 1992). Mollusks and mealybugs shipped to subtropical ports are more likely to be moved into a suitable habitat. The wide range of suitable climates for *S. litura* (CABI, 1999) means that it is highly likely to be moved to suitable climates.

The spores of the fungal pathogens are readily disseminated by a variety of mechanisms (Agrios, 1997; Pirone, 1978). Spores often require high relative humidity and moderate temperatures for limited periods of time to infect (Agrios, 1997). These conditions can be met during regular orchid culture conditions (Hartmann and Kester, 1959), so it is reasonable to expect that spores will find suitable habitats for infection. In China, *C. phalaenopsidis* caused an epidemic in orchids when environmental conditions of "cloudy and drizzly weather" occurred in the otherwise windless, hot and sunny climate (Lu *et al.*, 1994). Removal of diseased leaves along with application of pesticides from December to March provided control of the disease (Lu *et al.*, 1994). For all these reasons, this element is rated High (3) for all of the pests.

Risk Element 6, subelement 6: Contact with Host Material

All of the pests are highly likely to come into contact with host material if they enter the United States because the infested orchids are likely to be grown near other orchids indoors or in greenhouses. Additionally, the mollusk, mealybug, and *S. litura* have wide host ranges (CABI, 1999; Cox, 1989; Lai, 1984; Zhang, 1994), so native potential host plants are likely to be located near the locations where orchids are grown. Fungal spores are likely to be disseminated in indoor environments to other orchid plants by a variety of mechanisms (Agrios, 1997; Pirone, 1978). For all these reasons, this element is rated High (3) for all of the pests.

Table 6: Summary of the Risk Ratings for the Likelihood of Introduction

Pest	Quantity imported annually	Survive post-harvest treatment	Survive shipment	Not detected at port of entry	Moved to a suitable habitat	Find suitable hosts	Risk Rating
Acusta tourranensis	Low (1)	High (3)	High (3)	Low (1)	High (3)	High (3)	High (14)
Planococcus minor	Low (1)	High (3)	High (3)	Medium (2)	High (3)	High (3)	High (15)
Spodoptera litura	Low (1)	High (3)	High (3)	Medium (2)	High (3)	High (3)	High (15)
Cylindrosporium phalaenopsidis	Low (1)	High (3)	High (3)	Medium (2)	High (3)	High (3)	High (15)
Phomopsis orchidophila	Low (1)	High (3)	High (3)	Medium (2)	High (3)	High (3)	High (15)
Sphaerulina phalaenopsidis	Low (1)	High (3)	High (3)	Medium (2)	High (3)	High (3)	High (15)

F. Conclusion: Pest Risk Potential

The summation of the values for the Consequences of Introduction and the Likelihood of Introduction gives the values for the Pest Risk Potential (Table 7). The following scale is used to interpret this total: Low (11-18 points), Medium (19-26 points) and High (27-33 points). This is a baseline estimate of the risks associated with this importation, and reduction of risk occurs through the use of mitigation measures.

Table 7: Pest Risk Potential, Quarantine Pests of *Phalaenopsis* spp. From Taiwan.

Pest	Consequences of Introduction	Likelihood of Introduction	Baseline Pest Risk Potential
Acusta tourannensis	Medium (10)	High (14)	Medium (24)
Planococcus minor	Medium (11)	High (15)	Medium (26)
Spodoptera litura	High (15)	High (15)	High (30)
Cylindrosporium phalaenopsidis	Low (7)	High (15)	Medium (22)
Phomopsis orchidophila	Low (7)	High (15)	Medium (22)
Sphaerulina phalaenopsidis	Low (7)	High (15)	Medium (22)

Pests with a Baseline Pest Risk Potential value of Low may not require mitigation measures other than port of entry inspection, while values within the Medium or High range indicate that specific phytosanitary measures (in addition to port of entry inspection) are necessary to ensure phytosanitary security.

III. Risk Management

A. Introduction

The pest risks identified in the risk assessment (Table 4) represent a baseline risk associated with the unmitigated importation of *Phalaenopsis* orchids from Taiwan in APHIS-approved growing media. The proposed importation of *Phalaenopsis* orchids from Taiwan in APHIS-approved growing media, if approved, would be regulated by existing plants in growing media regulations [7 CFR § 319.37-8 (e)]. The mitigations described in 7 CFR § 319.37-8, comprise a "Systems Approach" designed to establish and maintain a pest-free production environment and ensure the use of pest-free parent plants. These mitigations, when applied to this importation, effectively remove the pests from the pathway, thus precluding them from establishment in the United States.

The Plant Protection Act of 2000 (SEC. 401. 7 U.S.C. 7701) defines "Systems Approach" as "…a defined set of phytosanitary procedures, at least two of which have an independent effect in mitigating pest risk associated with the movement of commodities." The FAO Draft Standard for Integrated Measures for Pest Risk Management proposed a definition of a Systems Approach as, "The integration of different pest risk management measures, at least two of which act independently, and which cumulatively achieve the desired level of phytosanitary protection." (FAO, 2001). Pest risk management is the decision-making process of reducing the risk of introduction of a quarantine pest (FAO, 1996). Systems Approaches are employed by an importing country as an alternative to the use of single measures that achieve an appropriate level of phytosanitary protection when a single phytosanitary measure is nonexistent, infeasible or undesirable. The combinations of specific mitigation measures that provide overlapping or sequential safeguards are distinctly different from single mitigation methodologies such as fumigation or inspection. Systems Approaches vary in complexity, however, they all require the integration of different measures, at least two of which act independently, with a cumulative effect and are often tailored to specific commodity-pest-origin combinations. Options for specific measures may be selected from a range of pre-harvest and post-harvest measures (*e.g.*, surveys, inspections, sanitation, chemical treatments, *etc*, and include mitigation measures to compensate for uncertainty. PPQ uses systems approaches for the importation of many commodities including Unshu oranges from Japan (7 CFR § 319.28), tomatoes from Spain, France, Morocco, and Western Sahara (7 CFR § 319.56-2dd), and peppers from Israel (7 CFR § 319.56-2u). These programs have performed successfully for many years.

The three main categories of mitigation measures specifically required by 7 CFR § 319.37-8 (e) for *Phalaenopsis* from Taiwan are: use of pest-free propagative material, pest-exclusionary greenhouses and inspection. Ensuring pest-free propagative material requires monitoring and testing of mother stock and descendant plants (Agrios, 1997; Jarvis, 1992). Pest-exclusionary greenhouses employ treatments, good sanitation, *e.g.*, surface disinfestation of tools and plant materials, *etc.* (Agrios, 1997; Jarvis, 1992; Hartman *et al*., 2002; Kahn and Mathur, 1999), clean water sources (Jarvis, 1992; Kahn and Mathur, 1999; Van der Plank, 1963), and use of approved growing media. Studies on APHIS-approved growing media found that pathogens are not present (Palm, 1994; Santacroce, 1991).

While not specifically required under 7 CFR§319.37-8(e), standard industry practices help to further ensure that the pests of concern do not follow the pathway. These include sanitation and chemical treatments designed to reduce or eliminate mealybugs (Cory and Highland, 1959), viruses (Gara *et al*., 1997; Inouye and Gara, 1996; Wey *et al*., 2001) and fungi (McCain *et al*., 1973); *in vitro* or aseptic vegetative propagation (Hsieh, 2001; Pearson, *et al.*, 1991). Other cultural practices enhance plant vigor so that pests are less able to establish infestations (Smith and Neal, 1998). These practices include proper lighting (Konow and Wang, 2001; Wang, 1995), temperature (Wey, 2002), aeration and watering (Frank, 1988; Miller, 1990), sanitation (Smith and Neal, 1998) and nutrition (Wang, 1998; Wang and Gregg, 1994). There are attempts to identify pest resistant varieties of *Phalaenopsis* (Chen and Hsieh, 1978).

B. General Program Requirements for Plants in Growing Media

Risk mitigation measures for *Phalaenopsis* plants from Taiwan are drawn from the general risk mitigation program requirements outlined in the APHIS regulation for certain plants in growing media are outlined in 7 CFR§ 319.37-8(e). That regulation states:

(1) Plants must be established in approved unused growing media.

(2) Articles must be grown in compliance with a written agreement for enforcement of this section signed by the plant protection service of the country of the country of origin and Plant protection and quarantine APHIS. The plants must be developed from mother stock which has been inspected no more than sixty days before establishment of the plants. The inspection will be performed by an APHIS inspector or an inspector of the plant protection service of the country of origin.

(3) The plants must be grown in compliance with a written agreement between the grower and the plant protection service of the country of origin. The grower must allow access to his facility to make sure he is complying with the regulations.

(4) Grown solely in a greenhouse in which sanitary procedures are employed to exclude plant pests and diseases. This includes cleaning and disinfection of tools and facilities and adequate measures to protect against plant pests and disease. The greenhouse must be free of soil and sand. It must have screens on all vents and opening of not more than 0.6mm. All entryways must be equipped with automatic closing doors.

(5) Rooted and grown in an active foliar state for at least four consecutive months before export. The greenhouse must be used solely for exports to the United States.

(6) Grown from seeds germinated in the greenhouse or descended from a mother plant that was grown for at least nine months in the exporting country. If the mother plant was imported into the exporting country then it must be grown for at least twelve months prior to establishment of the descendent plants or treated at the time of importation into the exporting country with a treatment for pests of the plant prescribed by the plant protection service of the exporting country and then grown for nine months prior to establishment of descendent plants.

(7) Watered only with rainwater that has been boiled or pasteurised, with clean well water or with potable water.

(8) Rooted and grown in approved growing media on benches supported by legs and raised at least 46cm off the floor.
(9) Stored and packed only in areas free of soil earth and plant pest.
(10) Inspected in the greenhouse and found free of evidence of plant pests and diseases by an APHIS inspector or an inspector of the plant protection service of the country of origin.

C. Program Safeguards to Ensure Compliance

As outlined above in **B. General Program Requirements for Plants in Growing Media**, the plants in growing media regulation 7 CFR§319.37-8(e) mandates certain procedures by APHIS and the plant protection service of the country of origin to ensure compliance with the regulation. A written agreement between the plant protection service of the country of origin and APHIS outlines the respective responsibilities and obligations for the enforcement of the various requirements of 7 CFR§319.37-8(e). This agreement is called the "Operational Work Plan". A current operational work plan for plants in growing media from the Netherlands is in place (APHIS, 2003). Before plants can be imported from Taiwan, a similar work plan will be developed and signed. The Netherlands operational work plan states how the program will be monitored and supervised to ensure compliance. The requirements, outlined in the Netherlands plants in growing media operational work plan, include:

- Officials from APHIS and the plant protection service of the Netherlands inspect each of the greenhouses as part of the approval process for admittance into the export program;
- APHIS monitors each of the approved greenhouses about four times a year but not more than once a month;
- The plant protection service of the Netherlands conducts monthly inspections of the approved facilities and provides APHIS with a monthly accounting of the growing stocks for each approved facility;
- The plant protection service of the Netherlands has a written compliance agreement with each approved grower;
- The plant protection service of the Netherlands conducts phytosanitary inspections (in the Netherlands), and issues and signs a Phytosanitary Certificate for each shipment;
- APHIS inspectors verify documentation and inspect the plants at a PPQ plant inspection station at a port of entry. Plant inspection stations are PPQ facilities located at certain ports of entry specifically designed and staffed to inspect imported propagative plant material. Propagative material is inspected carefully. The inspection is conducted in a clean, well-lit inspection room with hand lenses, large magnification lenses, and wide-field scopes available to the inspectors. The inspectional sample is large. It is generally larger then the sample for cut flowers and fruits, as large as 100 percent. The inspection process normally includes removing the plants from the medium and examining the roots.

D. Historical Performance of Existing Plants in Growing Media Import Programs

Current quarantine regulations 7 CFR§319.37-8(e) allow for plants of *Alstroemeria*, *Ananas*, *Anthurium*, *Begonia*, *Gloxinia*, *Peperomia*, certain ferns, rhododenrons from Europe and *Saintpaulia* to be imported into the United States in accordance with the measures described in Section B. The same measures that will apply to *Phalaenopsis* plants from Taiwan. In evaluating these risk management measures as they apply to *Phalaenopsis* plants from Taiwan, APHIS has reviewed (Miller, 2003) the performance record of the current program.

Summary of results of regular APHIS inspections of the greenhouses participating in the plants in growing media import program from 1990 to April 2003.

- In the Netherlands, two to four greenhouses (companies) have participated in the program. Both ferns and *Anthurium* have been grown and exported to the United States. Currently, three greenhouses are in the program. APHIS plant health specialists have inspected the greenhouses four to twelve times a year. They inspect for both noncompliance and plant pests. No plant pests were found on any of these visits.
- In Israel, one greenhouse growing ferns and African violets participated in the program between 1990 and 1994. This facility was inspected by APHIS plant health specialists from three to five times a year. Again, no plant pests were found.

All totaled, APHIS plant health specialists made approximately 200 inspectional site visits to participating greenhouses. No plant pest detections were made during any of these visits (Miller, 2003).

Additional greenhouse inspections.

In addition to the regular program inspections, on at least two different occasions participating greenhouses were visited by plant health specialists from the United States as part of general reviews of APHIS import programs.

In February 1984, two entomologists and a plant pathologist from PPQ inspected a program greenhouse in the Netherlands. No plant pests were found.

In March 1990, the Officer-in-Charge of the Plant Inspection Station at John F. Kennedy International Airport, NY, also carefully inspected a program greenhouse in the Netherlands and found no plant pests (Miller, 2003).

Port of Entry Inspections

Only one port of entry inspectional detection has been reported from program export plants. In 1990, a Lepidoptera larva was found in a single shipment. A very careful inspection of the originating greenhouse in the Netherlands failed to detect any pests and the interception was questioned (Miller, 2003). In comparison, there have been numerous interceptions during port of entry inspections of bare-rooted plants that are not required to enter under the proposed for plants in growing media (PPQ, 2003).

E. Evidence for the Effective Removal of Pests of Concern from the Pathway

Based on their characteristics, *e.g.*, respective biologies, methods of dispersal and ability to be detected, APHIS believes that the safeguards of 7 CFR§319.37-8(e) (see **B. General Program Requirements for Plants in Growing Media**) outlined above will result in the effective removal of the six pests of concern identified by the risk assessment from the *Phalaenopsis* plants from Taiwan pathway. The FAO (1999) defines pathway as "Any means that allows the entry or spread of a pest." The following paragraphs present the evidence APHIS used to determine that the measures required by 7 CFR§319.37-8(e) would effectively remove pests of concern from the *Phalaenopsis* plants from Taiwan pathway.

Acusta tourannensis

Acusta tourannensis has a tropical Asian distribution (Lai, 1984) and a host range that includes more than 10 families of plants (Lai, 1984). The adults of *A. tourrannensis* are large and likely to be dislodged from plants before transport (Godan, 1993; Ohlendorf, 1999). This snail feeds on Phalaenopsis spp. as well as other plants. It is known to be a tropical species. Snails and slugs are detectable by slime trails, chewed leaves and excrement (Hollingworth and Sewake, 2002). Standard inspection techniques are highly likely to detect larger mature and juvenile forms of the mollusk, *A. tourrannensis*, present on plants (Robinson, 2002). Although small eggs in soil are highly likely to escape detection, plants produced in APHIS-approved growing media under pest-exclusionary conditions (*e.g.,* sterile growing media) are expected to be free of mollusk eggs. The rule governing importation of plants in approved growing media [7 CFR§319.37-8(e)] reduces the risk of plants being contaminated by this species. Specific requirements (see **B. General Program Requirements for Plants in Growing Media**) that mitigate the risk of *A. tourrannensis* include:

Measure[1]	Evidence	Reference
1	Approved growing media is not a good pathway for snail movement.	(Hollingworth and Sewake, 2002)
2, 5, 10	All mother stock must be examined no more than sixty days before establishment and plants must be actively growing stage for four months. In addition, the orchids must be inspected in the greenhouse and found free of evidence of *A. tourrannensis* by an APHIS inspector or an inspector of the plant protection service of the country of origin. Snails are detectable by slime trails, chewed leaves and excrement. Since standard inspection techniques are highly likely to detect larger mature and juvenile forms of A. *tourrannensis*, this would allow snails to be found either before they move into the greenhouse or during required inspections.	(Robinson, 2002; Santacroce, 1991; CABI, 2002)
4, 7, 8, 9	Plants will be grown solely in greenhouses with sanitary procedures adequate to exclude mollusks and other plant pests, *e.g.*, there are no irrigation ditches or other openings in which the snails could gain access. The greenhouse must be free of soil and sand to prevent another potential pathway for entry of snails. In addition orchids must be stored and packaged in areas free of soil, sand, earth and	(Bessin, *et al.*, 1997; Hamon, 1995; Hollingworth and Sewake, 2002; van Rooyen, 2003)

Measure[1]	Evidence	Reference
	plant pests, which would further aid in eliminating snails from the pathway The requirement for a water source from clean well water, boiled rain water or drinking quality water will further reduce the likelihood of introducing mollusks. Growing the plants on raised benches is an additional physical barrier to snails that might inhabit the cool damp floor of the greenhouse.	

[1] see **B. General Program Requirements for Plants in Growing Media** for corresponding measure

Planococcus minor

The generalized life history of mealybugs (Pseudococcidae) indicates that the mobile young insects (crawlers) readily spread among closely placed plants (Cox, 1989; McKenzie, 1967; Williams and Granara de Willink, 1992). Ovipositing females are sedentary (Cox, 1989; McKenzie, 1967; Williams and Granara de Willink, 1992). The primary mode of long distance dispersal is through movement of live plants (CABI, 1999). *Planococcus minor* the mealybug of concern has only been intercepted once on *Phalaenopsis* and 3245 times on other hosts since 1985 (PPQ, 2003). This would indicate that *Phalaenopsis* is not a preferred host for *P. minor* and *Phalaenopsis* plants are a poor pathway for the introduction of *P. minor* into the United States.

Measure[1]	Evidence	Reference
2, 5, 10	All mother stock must be examined no more than sixty days before propagation of the export plants. Plants must be actively grown for four months. In addition, the orchids must be inspected in the greenhouse and found free of evidence of *P. minor* by an APHIS inspector or an inspector of the plant protection service of the country of origin. The white-bodied adults are about 2.0 mm long and are usually associated with black sooty mold. These physical features facilitate detection of *P. minor* on the green background of plants, as the numerous of port of entry interceptions attests. While young crawlers are so minute as to be difficult to detect, the four-month period of observation in the originating greenhouse will allow immatures to develop. Regular inspections are recognized as an important part of a balanced pest management program for orchids. The use of pest free propagating material is a primary measure to prevent the introduction of mealybugs into	(McKenzie, 1967; Cox, 1989; PPQ, 2003; Roosjen, *et al.*, 1999)

Measure[1]	Evidence	Reference
	greenhouse crops.	
4, 7	Plants will be grown solely in a greenhouse in which sanitary procedures are adequate to exclude plant pests. The greenhouse enclosure provides a physical barrier to plants' exposure to mealybugs from outside. Good greenhouse sanitation, *e.g.*, removal of plant debris, cleaning and disinfection of tools and facilities, *etc.* are essential safeguards commonly recommended to prevent mealybug infestations	(Roosjen, *et al.*, 1999; van Rooyen, 2003)

[1] see **B. General Program Requirements for Plants in Growing Media** for corresponding measure

Spodoptera litura

Spodoptera litura causes major damage to tobacco, cotton, chilies, cabbage, and other crops (Anon., 1982; CABI, 1999; CIE, 1993; Matsuura and Naito, 1992a; 1992b; Pogue, 2002). *Spodoptera* infestation usually occurs when adults fly into the production area to lay eggs (CABI, 2002).

Measure[1]	Evidence	Reference
2, 5, 10	All mother stock must be examined no more than sixty days before establishment and plants must be kept in an active growing stage for four months. In addition, the orchids must be inspected in the greenhouse and found free of evidence of *S. litura* by an APHIS inspector or an inspector of the plant protection service of the country of origin. The larvae of *S. litura* are from 2.3 mm to 32 mm in length and are on plant surfaces where they are readily detected. Newly emerged larvae can be easily detected by the "scratch marks" they make on the leaf surface. These physical features facilitate detection of *S. litura* as numerous port of entry interceptions attest. Eggs clusters which may be on cuttings are also readily detectable because they are laid in clusters of several hundred on the surface of the leaves. Eggs are 0.6 mm and the egg mass is 4 to 7mm in diameter. Generation time is approximately one month which would facilitate finding the insect during the four-month growing period. Regular inspections are recognized as part of a balanced pest	(Anon., 1982; CABI, 1999; CABI, 2002; CIE, 1993; Matsuura and Naito, 1992a; b; Pogue, 2002; Smith, *et al.*, 1997; Roosjen, *et al.*, 1999; van Rooyen, 2003)

Measure [1]	Evidence	Reference
	management program for orchids. The use of pest free propagating material is an effective measure to prevent the introduction of insects into greenhouse crops.	
4, 7	Plants will be grown solely in a greenhouse in which sanitary procedures are adequate to exclude plant pests. The greenhouse enclosure with its automatic double doors and screened vents provides a physical barrier to plants' exposure to insects from outside. Adult moths, which are 15mm to 20mm in length, are easily excluded by the required 0.6 mm mesh screening. Good greenhouse sanitation, *e.g.*, removal of plant debris, cleaning and disinfection of tools and facilities, *etc.* are essential safeguards commonly recommended to prevent insect infestations	(CABI, 2002; Roosjen, *et al.*, 1999; van Rooyen, A., 2003)

[1] see **B. General Program Requirements for Plants in Growing Media** for corresponding measure

Cylindrosporium phalaenopsidis
Phomopsis orchidophila
Sphaerulina phalaenopsidis

The fungal pathogens, *Cylindrosporium phalaenopsidis* and *Phomopsis orchidophila*, are in genera that produce spores that are splashed by irrigation or rain onto nearby hosts (Agrios, 1997; Pirone, 1978). These spores also may be carried by insects, animals, and humans moving among plants (Agrios, 1997; Pirone, 1978). *Sphaerulina phalaenopsidis* is in a genus that produces air dispersed spores that are not likely to be widely dispersed over long distances (Agrios, 1997). The pathogens, *C. phalaenopsidis*, *P. orchidophila* and *S. phalaenopsidis,* infect leaves causing leafspots (Agrios, 1997; Pirone, 1978; Rossman, *et al.*, 1987) that are easily detected by trained inspectors. PPQ interception records indicate that *P. orchidophila* was intercepted at ports of entry 53 times since 1985, with the majority of those interceptions made on orchid species, including two interceptions on *Phalaenopsis* sp. imported under the current bare root requirement (port of entry inspection only; PPQ, 2003). Fungi in the genera *Cylindrosporium* (five interceptions since 1985) and *Sphaerulina* (16 interceptions since 1985) have also been intercepted on various hosts (PPQ, 2003). The rules governing importation of plants in approved growing media reduce the risk of plants being contaminated by these species. Specific requirements of 7 CFR§319.37-8(e) (see **B. General Program Requirements for Plants in Growing Media**) that mitigate the risk of *C. phalaenopsidis*, *P. orchidophila* and *S. phalaenopsidis* include:

Measure [1]	Evidence	Reference
1	Fungal pathogens are generally introduced into the greenhouse via infested plant material or soil particles. The use of approved growing	(Barry, 1996; Daughtrey, *et al.*, 1995; McQuilken and Hopkins, 2001)

Measure[1]	Evidence	Reference
	media will prevent the introduction and / or spread of many fungal pathogens and is required.	
2, 5, 10	All mother stock must be examined no more than sixty days before establishment and plants must be kept in an active growing stage for four months. In addition, the orchids must be inspected in the greenhouse and found free of evidence of *C. phalaenopsidis*, *P. orchidophila* and *S. phalaenopsidis* by an APHIS inspector or an inspector of the plant protection service of the country of origin. The pathogens, *C. phalaenopsidis*, *P. orchidophila* and *S. phalaenopsidis,* infect leaves causing leafspots that are easily detected by trained inspectors. Regular inspections are recognized as part of a balanced disease management program for orchids. Fungal pathogens are generally introduced into the greenhouse via infested plant material or soil particles. The use of disease-free propagating material, as established by the required inspections of mother plants, is a primary measure to prevent the introduction of fungal pathogens into greenhouse crops.	(Agrios, 1997; Pirone, 1978; PPQ, 2003; Barry, 1996; Roosjen, *et al.*, 1999; Simone and Burnett, 1995; Daughtrey, *et al.*, 1995)
4, 7	Plants will be grown solely in a greenhouse in which sanitary procedures are adequate to exclude plant pests. The greenhouse enclosure provides a physical barrier to plants' exposure to fungal propagules from outside as the spores are rain splashed (*C. phalaenopsidis* and *P. orchidophila*) or windborne (*S. phalaenopsidis*). Good greenhouse sanitation, *e.g.*, removal of plant debris, cleaning and disinfection of tools and facilities, *etc.* are essential safeguards commonly recognized to prevent fungal infections and are required by the proposed program. The requirement for a water source from clean well water, boiled rain water or drinking quality water will further reduce the likelihood of introducing pathogens.	(Agrios, 1997; Pirone, 1978; Barry, 1996; Roosjen, *et al.*, 1999; Simone and Burnett, 1995)

[1] see **B. General Program Requirements for Plants in Growing Media** for corresponding measure

F. Conclusion

The mitigations described in 7 CFR § 319.37-8 (e) are designed to establish and maintain a pest-free production environment and ensure the use of pest-free parent plants. These mitigations, when applied to the importation of *Phalaenopsis* plants from Taiwan, effectively remove the pests of concern identified in the risk assessment from the pathway, thus precluding their introduction into the United States.

IV. References

Agrios, G. N. 1997. Plant Pathology, 4th Ed. Academic Press, Inc., NY.

Aguirre, W., and S. G. Poss. 2000. *Bradybaena similaris*. http://www.gsmfc.org/nis/nis/Bradybaena_similaris.html.

Anon. 1979. List of plant diseases in Taiwan. Plant Quarantine Bull. No. 6, Bureau Commodity Inspection and Quarantine, Ministry of Economic Affairs, Taiwan.

Anon. 1982. Rice cutworm, *Spodoptera litura* (F.). Pests Not Known to Occur in the United States or of Limited Distribution. No. 24. USDA, APHIS, PPQ, Hyattsville, MD.

APHIS. 2003. Netherlands Operational Work Plan, 2003. Plants in Growing Media Monitoring Program. On file with USDA, APHIS, PPQ, Riverdale, MD.

ARS. 1990. USDA Plant Hardiness Zone Map. USDA, ARS Misc. Publ. No. 1475. Washington, DC.

Barry, D.W., ed. 1996. Greenhouse Pesticide Management. Section 10 – Management of Greenhouse Diseases [Web page] http://www.ag.ndsu.nodak.edu/aginfo/pesticid/publications/GreenH/gpm-1.htm#Greenhouse Pesticide. *Last accessed May 1, 2003.*

Bessin, R., Townsend, L.H. and Anderson, R.G. 1997. Greenhouse Insect Management. Frankfort, KY: University of Kentucky, Cooperative Extension Service, Bulletin ENT 60. 6 pp.

Bradbury, J. F. 1986. Guide to Plant Pathogenic Bacteria. CAB International Mycological Institute.

Brunt, A., Crabtree, K. and A. Gibbs. 1990. Viruses of tropical plants. CAB. International and A.C.I.A.R. Wallingford, United Kingdom.

CABI. 1999. Crop Protection Compendium. CAB International, Wallingford, UK.

CABI. 2002. Crop Protection Compendium. CAB International, Wallingford, UK.

Cash, E. K. and A. J. Watson. 1955. Some fungi on Orchidaceae. Mycologia 47: 729-747.

Chang, N. T. 1987. Seasonal abundance and developmental biology of thrips *Megalurothrips usitatus* on soybean at southern area of Taiwan. Plant Protection Bull., Taiwan 29: 165-173.

Chen, J. S. and S. P. Y. Hsieh. 1978. *Phytophthora* black rot of *Phalaenopsis* in Taiwan. Plant Protect. Bull. 20: 161-170 [Abstr].

Chen, W. S. and F. L. Chan. 1987. Infestation of thrips on vegetables and their control. Chinese J. Ent. Spec. Pub. 1: 45-53.

Chieu, H. T. *et al*. 1991. Occurrence and damage of thrips in Citrus orchards in southern Taiwan. Chinese J. Ent. 11(4): 310-316.

CIE. 1993. Distribution maps of pests, Number 61, *Spodoptera litura*. CAB International, UK.

Cory, E. N. and H. A. Highland. 1959. Dipping *Phalaenopsis* for the control of mealybugs. Bull. Am. Orchid Soc. 28(5): 344-345 [Abstr].

Cox, J. M. 1989. Mealybug genus *Planococcus* (Homoptera: Pseudococcidae). Bull. British Museum Nat. Hist. (Ent.) 58(1): 1-78.

Daughtrey, M.L., Wick, R.L. and Peterson, J.L. 1995. Compendium of Flowering Potted Plant Diseases. St. Paul, MN: APS Press. 90 pp.

FAO. 1995. International Standards for Phytosanitary Measures. Section I, Import Regulations. Guidelines for Pest Risk Analysis, Rome, Italy.

FAO. 1996. Guidelines for Pest Risk Analysis. ISPM Pub. No.2, Rome, Italy.

FAO. 1999. International Standards for Phytosanitary Measures, Glossary of Phytosanitary Terms, ISPM Pub. No. 5, Rome, Italy.

FAO. 2001. International Standards for Phytosanitary Measures, Pest Risk Analysis for Quarantine Pests, ISPM Pub. No. 11, Rome, Italy.

Fahn, A. 1974. Plant Anatomy, 2nd ed. Pergamon Press, NY.

Farr, D. F., Bills, G. F., Chamuris, ,G. P. and A. Y. Rossman. 1989. Fungi on plants and plant products in the United States. American Phytopathological Society, St. Paul, MN.

Frank, D. W. 1988. Control of bacterial soft rot caused by *Pseudomonas cattleya* in the culture of *Phalaenopsis*. Orchid Digest 52: 66-67 [Abstr].

Gallegos, D. P. and E. J. Bonano. 1993. Consideration of uncertainty in the performance assessment of radioactive waste disposal from an international regulatory perspective. Reliab. Eng. System Safety, 42: 111-123.

Gara, I. W., Kondo, H. and T. Maeda. 1997. Evaluation of dot-immunobinding assay and rapid immunofilter paper assay for detection of cymbidium mosaic virus in orchids. Bull. Res. Inst. Bioresources 5: 39-46 [Abstr].

Godan, D. 1983. Pest slugs and snails: Biology and control. Springer-Verlag, Berlin, Germany.

Gunn, C. R. and C. A. Ritchie. 1982. Report of the Technical Committee to Evaluate Noxious Weeds; Exotic Weeds for the Federal Noxious Weed Act. (unpublished).

Hamon, A.B. 1995. Orchid Pests. In: Orchid Pests and Diseases. West Palm Beach, FL: American Orchid Society. Pg. 45-46.

Hamon, A. B. and M. L. Williams. 1984. Soft Scale Insects of Florida (Homoptera: Coccoidea: Coccidae). Arthropods of Florida and Neighboring Land Areas. Bureau Entomol. Florida Dept. Agric. Consumer Serv., Gainesville, FL.

Hartmann, H. T. and D. E. Kester. 1959. Plant Propagation, 3rd ed. Prentice-Hall, Inc., NJ.

Hollingsworth, R.G. and Sewake, K.T. 2002. The Orchid Snail as a Pest of Orchids in Hawaii. Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa. Miscellaneous Pests, MP-1.

Holm, L. G., Plucknett, D. L., Pancho, J. V. and J. P. Herberger. 1977. World's worst weeds: Distribution and biology. University of Hawaii Press, Honolulu.

Holm, L. G., Pancho, J. V., Herberger, J. P. and D. L. Plucknett. 1979. Geographical atlas of world weeds. John Wiley and Sons, NY.

Hsieh, S.-C. 2001. Taiwan Assisted Flower Production and Marketing in Paraguay. [Web page] http://www.icdf.org.tw/web_pub/20020729155737Paraguay%20Final.pdf. *Last accessed May 1, 2003.*

Inouye, N. and I. W. Gara. 1996. Detection and identification of viruses of orchids in Indonesia. Bull. Research Instit. Bioresources 4: 109-118 [Abstr].

Jarvis, W.R. 1992. Managing diseases in greenhouse crops. St. Paul, MN: APS Press.

Jeppson, L. R., Keifer, H. H. and E. W. Baker. 1975. Mites Injurious to Economic Plants. University of California Press, Berkeley.

Kahn, R.P. and Mathur, S.B. 1999. Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests. APS Press, MN.

Kaplan, S. 1992. 'Expert information' versus 'expert opinions.' Another approach to the problem of eliciting/combining/using expert knowledge in PRA. Reliab. Eng. System Safety, 35: 61-72.

Konow, E. A. and Y. T. Wang. 2001. Irradiance levels affect *in vitro* and greenhouse growth, flowering, and photosynthetic behavior of a hybrid *Phalaenopsis* orchid. J. Am. Soc. Hort. Soc. 126(5): 531-536 [Abstr].

Lai. K. Y. 1984. Study on morphology and ecology of the land snail *Acusta tourannensis* (Souleyet). Bull. Malacology, *Republic of China* 40-41.

Lu, S. J., Xie, J. N., Lin, T. Z., Jiang, Z. D. and P. K. Qi. 1994. Study on the black spot of *Cymbidium sinesis* (Andr.) Willd. Acta Phytophylacica Sinica. 21: 91-96 [Abstr.].

Matsuura, H. and A. Naito. 1992a. Studies on the cold-hardiness and overwintering of *Spodoptera litura* F. (Lepidoptera: Noctuidae). IV. Daily activity rhythm of larvae in winter. Japanese J. Appl. Entomol. Zool. 36(1): 31-35.

Matsuura, H. and A. Naito. 1992b. Studies on the cold-hardiness and overwintering of *Spodoptera litura* F. (Lepidoptera: Noctuidae). V. Possibility of larval and pupal overwintering at the southern extremity of the Boso Peninsula. Japanese J. Appl. Entomol. Zool. 36(1): 37-43.

McCain, A.H., Sciaroni, R. H. and V. M. Muir. 1973. Control of *Pythium* rot of *Phalaenopsis* seedlings. Ill. State Florists Assoc. Bull. No. 341, p. 2-4 [Abstr].

McKenzie, H. L. 1967. Mealybugs of California. University of California Press, Berkeley.

McQuilken, M.P. and Hopkins, K.E. 2001. Sources, survival and management of *Pestalotiopsis sydowiana* on *Calluna vulgaris* nurseries. Crop Protection **20**: 591-597.

Miller, C.E. 2003. Notes on the Effectiveness of the Risk Mitigation Measures of 7CFR§319.36-8(e). On file with USDA, APHIS, PPQ, Riverdale, MD.

Miller, J. W. 1990. Bacterial brown spot of orchid caused by *Pseudomonas cattleyae*. Plant Pathol. Circ. No. 330, Florida Dept. Agric. Consumer Services.

Morgan, M. G. and M. Henrion. 1990. Uncertainty. Cambridge University Press, UK.

Nakahara, S. 1982. Checklist of the Armored Scales (Homoptera; Diaspididae) of the Conterminous United States. USDA, APHIS, PPQ.

NAPPO. 1995. NAPPO Compendium of Phytosanitary Terms, North American Plant Protection Organization, Ontario, Canada.

National Climatic Data Center. 2000. Global climate norms, 1961-1990. Asheville, NC.

Ohlendorf, B. (Ed). 1999. Pest Notes: Snails and Slugs, Pub. No. 7427. University of California Statewide IPM Program, http://www.ipm.ucdavis.edu.

Palm, M. 1994. Analysis of Growing Media from China (personal communication to Rebecca Bech summarizing isolating only saprophytes such as yeasts, bacteria, *Aspergillus*, and *Penicillium* from mixtures of peat, vermiculite, zeolite, coal cinder, and perlite from China) on file with USDA, APHIS, PPQ, CPHST, PERAL.

Paull, R. E. and J. W. Armstrong (Eds). 1994. Insect Pests and Fresh Horticultural Products: Treatments and Responses. CAB International., United Kingdom.

Pearson, M.N., Jackson, G.V.H., Zettler, F.W. and Frison, E.A. (Eds.) 1991. *FAO/IBPGR Technical Guidelines for Safe Movement of Vanilla Germplasm.* Food and Agriculture Organization of the United Nations, Rome / International Board for Plant Genetic Resources, Rome. 17 pp.

Pirone, P. P. 1978. Diseases and Pests of Ornamental Plants, 5th Ed. John Wiley and Sons, NY.

Pogue, M. G. 2002. World revision of the genus *Spodoptera* Guenee (Lepidoptera: Noctuidae) Mem. Amer. Entomol. Soc. No. 43.

PPQ. 1998. Interception database records for *Phalaenopsis* orchids from Taiwan, 1985-1997.

PPQ. 2003. Port Interception Network database. USDA, APHIS, PPQ, Riverdale, MD.

Redlin, S. C., USDA, APHIS, Plant Pathologist. 2002. E-mail communication. Official response from Taiwan Government re: *Phalaenopsis* orchids, May 01, 2002.

Reed, C. F. 1977. Economically important foreign weeds: potential problems in the United States. USDA Agric. Handbook 498, Washington, DC.

Robinson, D., USDA, APHIS, Mollusk Identifier. 2002. E-mail communication with M. Hennessey, April 2, 2002.

Roosjen, M.G., Stigter, M. and Oomen, P.A. 1999. Greenhouse Pest Exclusion and Eradication Safeguards and Principles. In: Kahn, R.P. and Mathur, S.B., eds. Containment Facilities and Safeguards for Exotic Plant Pathogens and Pests. St. Paul, MN: APS Press. Pgs. 182-185.

Rossman, A.Y., Palm, M.E. and Spielman, L.J. 1987. A Literature Guide for the Identification of Plant Pathogenic Fungi. St. Paul, MN: APS Press. 252 pp.

Santacroce, N.G. An Evaluation of Pests Associated with Packaged Peat . Rock Wool and Expanded Clay in Greenhouse Production. Hyattsville, MD: U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Biological Assessment and Taxonomic Support.

Sawada, K. 1959. Descriptive catalogue of Taiwan (Formosan) fungi. Spec. Publ. Coll. Agr. Taipei, Taiwan 59: 1-268.

ScaleNet. 2002. http://www.sel.barc.usda.gov/scalecgi.

Simone, G.W. and Burnett, H.C. 1995. Diseases Caused by Bacteria and Fungi. In: Orchid Pests and Diseases. West Palm Beach, FL: American Orchid Society. Pg. 50-73.

Smith, E. S. C. and M. J. Neal. 1998. Eradication of the orchid weevil *Orchidophilus aterrimus* (Waterhouse) (Coleoptera: Curculionidae) from the NT. Proc. 6th Workshop Tropical Agric. Entomol., Australia [Abstr].

Smith, I. M., Dunez, J. Phillips, D. H., Lelliott, R. A. and S. A. Archer. 1988. European Handbook of Plant Diseases. Blackwell Scientific Publications, Oxford, UK.

Smith, I. M., McNamara, D. G., Scott, P. R. and K. M. Harris (Eds). 1992. Quarantine Pests for Europe. EPPO and CAB International, UK.

Sneh, B., Burpee, L. and A. Ogoshi. 1991. Identification of *Rhizoctonia* species. APS Press, MN.

Taiwan. 1996. Pest list from Ching-Wen Kuo enclosed with correspondence to J. Thaw. August 26, 1996.

Tandon, P. L. and V. A. Verghese. 1987. New insect pests of certain fruit crops. Indian J. Hort. 44: 121-122.

Tang., C. C. 1976. Ecological studies on green asparagus thrips, *Frankliniella intonsa* Trybom in Taiwan. J. Agric. Res. China. 25(4): 299-309.

Taylor, L. and T. D. Bruns. 1994. View of specificity in orchid mycorrhizae using molecular symbiont identification. 5th Intl. Mycol. Congress, Canada [Poster] http://plantbio.berkeley.edu/~bruns/text/poster.html

Tu, W. G., Wu, W. J. and P. P. Lee. 1988. Planococcini of Taiwan (Homoptera: Pseudococcidae) Ann. Taiwan Museum 31: 71-102.

Uecker, F. A. 1988. World list of *Phomopsis* names with notes on nomenclature, morphology and biology. Mycologia Memoir 13, Berlin, Germany.

USDA. 1995. Pathway-initiated pest risk assessment: Guidelines for qualitative assessments version. 4.0, USDA, APHIS, Riverdale, MD.

USDA. 1997. Risk Assessment of Importation of Moth Orchid (*Phalaenopsis* spp.) Seedlings from Taiwan in Growing Media into the United States.

USDA. 1998. Importation of Orchids in Growing Media; Proposed Rule. 63 Fed. Reg. 46403, September 1, 1998.

USDA. 2000. Guidelines for Pathway-Initiated Pest Risk Assessments version 5.02, USDA, APHIS, Riverdale, MD.

USDA. 2002. Florida Agricultural Statistics Service. http://www.usda.gov/fl.

USFWS. 2001. Threatened and Endangered species system. U.S. Fish and Wildlife Serv. http://ecos.fws.gov/webpage.

Van der Plank, J. E. 1963. Plant Diseases: Epidemics and Control. Academic Press, NY.

van Rooyen, A. 2003. Growing Orchids. [Web page] <www.orchidssa.co.za/growingo.htm> *Last accessed May 1, 2003.*

Wang, C. L. 1987. Infestation of thrips on floriculture and their control. Chinese J. Ent. Spec. Pub. 1: 37-43.

Wang, Y. T. 1998. Impact of salinity and media on growth and flowering of a hybrid *Phalaenopsis* orchid. HortSci. 33(2): 247-250.

Wang, Y. T. and L. L. Gregg. 1994. Medium and fertilizer affect the performance of *Phalaenopsis* orchids during two flowering cycles. HortSci. 29(4): 269-271 [Abstr].

Wey, G. C. 2002. Relationship among yellow ring spot on *Phalaenopsis* leaves and species, causal agents and temperature. Taiwan-Sugar 49: 19-27 [Abstr].

Wey, G. C.; Shyuu, T. Y. and W. H. Chen. 2001. Occurrence and integrated control of *Phalaenopsis* virus diseases. Taiwan-Sugar 48: 22-29 [Abstr].

Willems, A., Goor, M., Thielemans, M., Kerster, K. and J. DeLey. 1992. Transfer of several phytopathogenic *Pseudomonas* species to *Acidovorax* as *Acidovorax aveanae* subsp. *avenae* subsp. nov., comb. nov., *Acidovorax avenae* subsp. *citrulli*, *Acidovorax avenae* subsp. *cattleyae*, and *Acidovorax konjaci*. Int. J. Syst. Bacteriol. 42: 107-119.

Williams, D. J. 1982. Distribution of the mealybug genus *Planococcus* (Hemiptera: Pseudococcidae) in Melanesia, Polynesia and Kiribati. Bull. Ent. Res. 72: 441-455.

Williams, D. J., and M. C. Granara de Willink. 1992. Mealybugs of Central and South America. CAB Intl., UK.

WSSA. 2002. Noxious weed list. http://www.usda.ars.gov.

Wu, S. K. 1982. Note on *Eulota tourannensis* (Souleyet) (Gastropoda: Pulmonata) of Taiwan. Venus 41(1): 26-32.

Zachariah, C. P. 1991. Successfully growing *Phalaenopsis* in New Zealand sphagnum. Am. Orchid Soc. Bull. 60: 885-887.

Zettler, F. W., Ko, N. J., Wisler, G. C., Elliott, M. S. and S. M. Wong. 1990. Viruses of orchids and their control. Plant Dis. 74: 621-626.

Zhang, B. C. 1994. Index of economically important Lepidoptera. CAB International, Wallingford, UK.

V. Authors

Risk Assessment
Gary L. Cave, Ph.D., Entomologist, USDA, APHIS, PPQ, CPHST, PERAL
Scott C. Redlin, Ph. D., Plant Pathologist, USDA, APHIS, PPQ, CPHST, PERAL
Russell Stewart, Entomologist, USDA, APHIS, PPQ

Risk Management
William E. Thomas, Import Specialist, USDA, APHIS, PPQ, PIM
Charles E. Miller, Senior Entomologist, USDA, APHIS, PPD, RAS
Edward V. Podleckis, Ph.D., Lead Risk Mitigation Specialist, USDA, APHIS, PPQ, PHP
Shaharra J. Usnick, Ph.D., Risk Mitigation Specialist, USDA, APHIS, PPQ, PHP

Reviewers/Contributors
Ron A. Sequeira, USDA, APHIS, PPQ, CPHST
Michael K. Hennessey, Ph.D., Entomologist, USDA, APHIS, PPQ, CPHST, PERAL
Hossien M. El-Nashaar, Ph. D., Plant Pathologist, USDA, APHIS, PPQ, CPHST, PERAL
Stacy Scott, Botanist, USDA, APHIS, PPQ, CPHST, PERAL
Eileen Sutker, Ph. D., Ecologist, USDA, APHIS, PPQ, CPHST, PERAL
Wayne Burnett, Team Leader, USDA, APHIS, PPQ, PIM, IIS