POTENTIAL PEST MITE SPECIES COLLECTED ON ORNAMENTAL PLANTS FROM CENTRAL AMERICA AT PORT OF ENTRY TO THE UNITED STATES

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ABSTRACT

Twenty-four plant shipments arriving via air cargo from Guatemala, Honduras, and Costa Rica to Miami International airport in Florida, were sampled on February 6-7, 2003. Random samples of rooted plants or cuttings were washed in 80% ethanol to collect the mite species present. Altogether 81 mites in 11 families were identified in 12 plant shipments (i.e., 50% of the 24 shipments sampled were found to contain mites). Plant mite pests included *Brevipalpus phoenicis* (Geijskes), *Fungitarsonemus* sp., *Polyphagotarsonemus latus* (Banks), *Tarsonemus* sp., *Tarsonemus confusus* Ewing, *Tetranychus urticae* Koch, *Tetranychus* sp., and *Rhizoglyphus* sp. (Acaridae). These mites, recovered from a variety of ornamental plant genera, are potentially serious pests. Of special importance is *B. phoenicis* because it is a known vector of citrus leprosis and several related viruses of ornamental plants that occur in Central and South America. A dilemma exists because many of these diseases, including citrus leprosis, do not occur in the United States, but potential vectors are already present. Relevant needs include (a) a special sampling program for mites on live plant materials received at ports of entry, (b) new legislation that requires imported plant propagules to be free of pest species of mites, and (c) mandatory risk mitigation in nurseries abroad where shipments originate and pre-clearance at the port of export.

Key Words: Acari, Acaridae, Tenuipalpidae, Tarsonemidae, Tetranychidae, virus-like diseases, citrus leprosis

RESUMEN

Veinte cuatro cargamentos de plantas llegandos del cargo por avion de Guatemala, Honduras, y Costa Rica al Aeropuerto Internacional de Miami en Florida, fueron muestreados en el 6-7 de febrero de 2003. Muestras tomadas al azar de plantas arraigadas o cortadas fueron lavadas en 80% de etanol para recolectar los ácaros presentes. Un total de 81 ácaros en 11 familias fueron identificados en 12 cargamentos de plantas. La mitad de los 24 cargamentos muestreados de Guatemala, Honduras, y Costa Rica tenian ácaros. Los acaros plaga de plantas incluyeron: *Brevipalpus phoenicis* (Geijskes), *Fungitarsonemus* sp., *Polyphagotarsonemus latus* (Banks), *Tarsonemus* sp., *Tarsonemus confusus* Ewing, *Tetranychus urticae* Koch, *Tetranychus* sp., y *Rhizoglyphus* sp. (Acaridae). Estos ácaros, recuperados de una variedad de géneros de plantas ornamentales, son plagas potencialmente serias. De importancia especial es *B. phoenicis* por ser conocido como vector de leprosis de citricos y varios virus relacionados con plantas ornamentales que ocurren en sudamerica y centroamerica. Muchas de estas enfermedades, incluyendo la leprosis de los citricos, no ocurren en los Estados Unidos. Un dilema existe para la agricultura de este pais porque el ácaro vector ocurre dentro de los Estado Unidos mientras que el leprosis de los citricos no ocurre en los Estados Unidos. Las necesidades pertinentes incluyen (a) un programa de muestreo especial para los ácaros sobre material de plantas vivas recibidas en los puertos de entrada, (b) nueva legislación que requiere que plantas importadas para propagación sean libres de especies de ácaros que son plagas, y (c) mitigación de riesgo mandatorio en los viveros fuera del país donde se origen los cargamentos y pre-aprobación en el puerto de exportación.

More than 205 non-indigenous species (NIS) have been introduced or first detected within the United States between 1980 and 1993, and 59 are expected to cause economic or environmental harm (Office of Technology Assessment 1993). The establishment of exotic arthropods at least in Florida has continued at an alarming rate (Thomas 2000). The potential economic losses from these introductions were predicted to be immense and have been proven in Florida with the devastation produced by only a few examples of exotic introductions (e.g., the bacterium, *Xanthomonas axonopodis* pv. *citri*, that causes citrus canker; the citrus leafminer, *Phyllocnistis citrella* Stainton; and the brown citrus aphid, *Toxoptera citricida* (Kirkaldy)). These and other exotic pest introductions have resulted in significant economic losses to the Florida citrus industry.

Since 1987, at least 14 exotic mites have been discovered in Florida (Thomas 2000; W. C. Welbourn, Florida Department of Agriculture and Consumer Services, Division of Plant Industry,

unpublished). Table 1 lists the reported exotic pest mite introductions into the United States within the past three decades. Two of these (*Varroa destructor* Anderson & Trueman and *Acarapis woodi* (Rennie)) have resulted in the near elimination of feral honey bees (*Apis mellifera* L.). Also, significant economic losses have resulted in reduced availability of managed bees that are essential for pollinating many crops within the United States (Robinson et al. 1989a, b; Sammataro et al. 2000).

We have entered an era of unprecedented levels of travel and international commerce (Klassen et al. 2002). With these increases has come corresponding increases in the movement of pests once considered exotic. Klassen et al. (2002) estimated that there are 130 significant arthropod pests present in the Caribbean. Therefore, Florida ranks near the top of states at risk from pest introductions due to its position relative to the Caribbean, which is the only region of the globe without an active regional safeguarding organization.

Dobbs and Brodel (2004) reported an overall infestation rate of 10.4% of hitchhiking insect species in cargo aircraft arriving at the Miami International airport between September 1998 and August 1999. However, the rate of insect infested aircraft arriving from Central America was 23%. Other factors relating to exotic pest introduction are involved, including the movement of substantial amounts of live plants into Florida for use as propagative materials in the ornamental industry.

Approximately 85% of all live plant materials imported into the United States are ornamentals grown in Central America and shipped into Florida through the Miami International Airport (Frank & McCoy 1995). During 2003, plants processed at the Miami Inspection Station constituted 72% of the total numbers of imported ornamentals into the United States (USDA, APHIS, Miami Interception Records 2004). Los Angeles processed 17% of all U.S. ornamental shipments with the remaining 11% processed by all other U.S. ports combined. The rate of growth for such shipments is estimated to double every 6 years (Klassen et al. 2002). The plants are shipped into Florida through the United States Department of Agriculture Animal, Plant, and Health Inspection Service, Plant Protection and Quarantine (USDA-APHIS-PPQ), Plant Inspection Station in Miami as cuttings or rooted plants for propagation and distribution. Between October 2003 and September 2004 more than 1 billion plants were shipped from Central America, Mexico, South America, Asia, and Europe with 63% coming from Central American countries (USDA APHIS Miami Work Accomplishment Data System 2004). Miami received over 859 million of these plant units. Propagative plant material is but one

TABLE 1. LIST OF NON-INDIGENOUS SPECIES OF MITES INTRODUCED INTO THE UNITED STATES SINCE 1980.

Mite superfamily or family	Mite species	Scientific name	Pathway or distribution
Prostigmata			
Eriophyidae		*Aculops fuchsia* Keifer	on plants[1]
		Acalitus ipomocarneae Keifer	on plants[3]
		Aceria litchii Keifer	on plants[3]
		Aceria zelkoviana Kim	on plants[3]
		Cecidophyopsis n. sp.	on plants[3]
		Tegolophus perseaflorae Keifer	on plants[3]
		Vittacus bougainvilleae Abou-Awad & El-Banhawy	on plants[3]
Phytoptidae		*Acathrix trymatus* Keifer	on plants[3]
Tarsonemidae	Honeybee tracheal mite	*Acarapis woodi* (Rennie)	honeybees[1]
Tenuipalpidae	Flat scarlet mite	*Cenopalpus pulcher* (Camestrini & Fanzago)	apples and pears in Benton and Linn Counties in Oregon[2]
Tetranychidae		*Oligonychus perseae* Tuttle, Baker & Abatiello	on plants[1]
		Oligonychus grypus Baker & Prichard	sugarcane[3]
		Eutetranychus sp.	on plants[3]
Mesostigmata			
Laelapidae		*Melittiphis alveartus* (Berlese)	honeybees[1]
Varroidae	Varroa mite	*Varroa destructor* Anderson & Trueman	honeybees[1,3]

[1]Office of Technology Assessment 1993
[2]Bajwa et al. 2001
[3]Thomas 2000

of several pathways for potential introduction of single or multiple pest mites and the diseases they may vector into the United States.

There are over 1,000 exotic pest mite species of potential agricultural, sylvan, or ornamental importance to the United States within the acarine families: Acaridae, Eriophyidae, Diptilomiopidae, Laelapidae, Nalepellidae, Penthaleidae, Siteroptidae, Tarsonemidae, Tenuipalpidae, Tetranychidae, Tuckerellidae, and Varroidae (Jeppson et al. 1975; Lindquist 1986; Ochoa et al. 1994; C. C. Childers et al., Citrus Research and Education Center, University of Florida, unpublished). The Acaridae, Eriophyidae, Tarsonemidae, Tenuipalpidae, Tetranychidae, and Tuckerellidae have several exotic pests of potential importance within the Caribbean and Central American countries. Mite-vectored diseases such as citrus leprosis and other related virus-like pathogens pose additional threats. These concerns prompted officials from the USDA-APHIS-PPQ to support a preliminary survey (i.e., the present study) to identify pest mite species present on imported plants.

Citrus leprosis is a serious viral disease caused by two different viruses (one nuclear and the other cytoplasmic). These two viruses differ morphologically yet result in similar disease symptoms in citrus (Rodrigues et al. 2003). *Citrus* species, especially oranges (*Citrus sinensis* (L.) Osbeck), are highly susceptible to infection by citrus leprosis virus. Mandarins (*C. reticulata* Blanco, *C. reshni* Hort. ex Tanaka, *C. deliciosa* Tenore) and hybrids such as 'Murcott' are considered much less susceptible under natural and experimental conditions (Rodrigues 1995). Both viruses can kill sweet orange trees if the *Brevipalpus* mite vector is not controlled with acaricides.

Identification of citrus leprosis disease in affected tissues is achieved with transmission electron microscopy (TEM), the only accurate method confirming both viral infections at this time. Therefore, identifications based solely on visual symptoms should not be used. Molecular primers are only available to detect the cytoplasmic virus type (Locali et al. 2003).

Citrus leprosis is known to occur in South America. The disease has been recently identified in Panama (Dominguez et al. 2001), Costa Rica (Araya-Gonzales 2000), Honduras (J. C. V. Rodrigues et al., Citrus Research and Education Center, University of Florida, unpublished), and Colombia (D. S. Achor et al., Citrus Research and Education Center, University of Florida, unpublished). Citrus leprosis reportedly occurs in Guatemala (Mejia et al. 2002). This places parts of Mexican citrus production at risk and ultimately United States citrus production. The disease is believed to have occurred in Florida and disappeared sometime prior to 1962 (Childers et al. 2003a).

The purpose of this survey was to identify mite species found within selected ornamental samples from Central America being shipped into the United States. We were especially interested in possible contamination of one or more shipments with *B. phoenicis* (Geijskes) or other species within the genus *Brevipalpus* because of their involvement as vectors of several virus-like diseases of citrus and ornamental plants. *Brevipalpus phoenicis* occurs within the United States. However, many of the diseases this genus vectors are not present in the U.S. and pose considerable risk to both the citrus and ornamental industries within the United States.

Materials and Methods

Twenty-four plant shipments arriving by air cargo to Miami, Florida International Airport were selected at random from a list of 486 known host plants of *B. phoenicis* on February 6-7, 2003 (Childers et al. 2003c). The samples included *Hedera* spp., *Scindapsus* sp., *Peperomia* sp., *Codiaeum* spp., including *C. variegatum* (L.) Blume, *Dracaena* spp., including *D. godseffiana* Hort., *Schefflera arboricola* (Hyata) Merrill, *Cordyline terminalis* Kuth, and various species of Orchidaceae.

The 24 shipments sampled represented a minimum of 1,200 to 2,400 plants from the 1.6 million shipped from Costa Rica, 3.5 million from Guatemala and the 71,210 plants from Honduras that arrived on February 6-7, 2003 to Miami (USDA APHIS Miami Work Accomplishment Data System 2004). These dates were within the peak season for live plant imports that occurs during January and February from these Central American countries. Selection of February 6 and 7 as sampling dates was done based on our availability during that time.

Propagated plants were usually shipped in cardboard boxes in groups (usually 10-1,000 plants of the same species depending upon individual plant size) and wrapped in newspapers. Each box can vary considerably in size. Many boxes that we sampled were 60 to 90 cm long × 45 to 90 cm wide × 45 to 90 cm deep. The number of plants per shipment varies greatly and depends on the grower and plant material being shipped. Shipments are very often larger than 12 boxes from one exporter and may include more than one plant type. Each box that we sampled contained variable numbers of bundled plant materials usually of the same genus.

One bundle of rooted plants or cuttings per plant type per shipment was selected, washed and vigorously agitated in a bucket containing about one liter of 80% ethanol. The plant materials were then discarded and the alcohol wash was saved with the label information for that ornamental plant, grower, and country of origin. Each alcohol sample was then poured into a black Petri dish divided into a multiple 1-cm^2 grid and examined with a stereomicroscope (10-50× magnification) for the

presence of mites. Ornamental plant species sampled that were not infested with mites were not recorded. All mites from each sample were slide-mounted in Hoyer's mounting medium (Krantz 1978). The slides were oven-cured at 43-45°C for 2 weeks and then the preserved specimens were identified. Species within the mite families Tenuipalpidae, Tarsonemidae, Histiostomatidae, and Acaridae were identified by Dr. R. Ochoa. Species within the families Tetranychidae and Tydeidae were identified by Dr. W. C. Welbourn.

Results

A very low number of plants were sampled for pest mites on February 6-7 compared with the 5.2 million plants shipped into Miami from Costa Rica, Guatemala, and Honduras. A total of 81 mites in 11 families were identified in 12 ornamental plant shipments from 9 growers in Guatemala, Honduras, and Costa Rica even with this modest sample size (Table 2). Of the 24 plant shipments examined, half contained at least one mite. One sample of *Dracaena godseffiana* and one of *Codiaeum* sp., both from Guatemala, contained one or more *B. phoenicis*. Other potential plant pest mites found were in the families Tarsonemidae, Tetranychidae, and Acaridae.

Discussion

Small arthropods including mites desiccate rapidly when they die because of their large surface area to volume ratios. Generally, mite body parts

Table 2. List of Acari collected from live ornamental plant shipments sampled from Costa Rica, Guatemala, and Honduras during february 6 and 7, 2003 at the USDA APHIS-PPQ Miami plant inspection station.

Country of origin	Shipper	Ornamental plant infested	Acarine species collected
Guatemala	Grower 1	*Dracaena godseffiana* Hort.	*Brevipalpus phoenicis* (Geijskes)[1] (Tenuipalpidae)—1 specimen; *Brevipalpus* sp.[1](Tenuipalpidae)—1 specimen
Guatemala	Grower 1	*Dracaena godseffiana* Hort.	Eupodidae—1 specimen; *Lorryia formosa* Cooreman (Tydeidae)—1 specimen
Guatemala	Grower 2	*Codiaeum variegatum* (L.) Blume	*Brevipalpus phoenicis*[1] (Tenuipalpidae)—2 specimens; *Fungitarsonemus* sp.[2] (Tarsonemidae)—2 specimens; *Lorryia formosa* (Tydeidae)—1 specimen; Tydeidae (larva)—1 specimen
Guatemala	Grower 3	*Peperomia* sp.	*Polyphagotarsonemus latus* (Banks)[2] (Tarsonemidae)—3 specimens
Guatemala	Grower 3	*Scindapsus* sp. (Hawaiian Pothus)	*Tarsonemus* sp.[2] (Tarsonemidae)—1 specimen; *Tarsonemus confusus* Ewing[2] (Tarsonemidae)—1 specimen; *Tarsonemus* n. sp.[2] (Tarsonemidae)—1 specimen
Guatemala	Grower 3	*Scindapsus* sp. (Marble Jade)	*Tarsonemus confusus*[2] (Tarsonemidae)—1 specimen; *Parapronematus* sp. (Tydeidae)—2 specimens; Tydeidae (larva)—1 specimen
Guatemala	Grower 4	*Schefflera* sp.	Camerobiidae—1 specimen (probably predacious); Orbatidae—1 specimen; *Lorryia formosa* (Tydeidae)—1 specimen
Guatemala	Grower 5	*Schefflera* sp.	*Metapronematus* sp. (Tydeidae)—1 specimen
Honduras	Grower 6	Mastasde [?]	Histiostomatidae—1 specimen
Costa Rica	Grower 7	*Codiaeum* sp. (Sunny Star)	*Rhizoglyphus* sp.[2] (Acaridae)—1 specimen; *Tetranychus* sp.[2] (Tetranychidae) –14 specimens
Costa Rica	Grower 8	*Schefflera arboricola* (Hayata) Merrill	Phytoseiidae—1 specimen (predacious mite)
Costa Rica	Grower 9	*Cordyline terminalis* Kuth (*Calypsa*)	Bdellidae—1 specimen (predacious mite); *Tetranychus urticae* Koch[3] (Tetranychidae)—6 specimens; (Tetranychidae)—4 specimens—probably *Tetranychus urticae*[3]; *Tetranychus* sp.[4] (Tetranychidae)—29 specimens

[1]Plant pests and potential vectors of citrus leprosis and related ornamental viruses.
[2]Plant pests.
[3]Plant pest occurring in USA.
[4]Plant pests-only females and immatures present and males required to verify species.

are rapidly fragmented after death or whole mites become misshapen, dried out, and lose their body color. This is especially true for soft-bodied phytophagous mite species in the families Tetranychidae and Tenuipalpidae. In contrast, live, healthy mites retain their body shape, size, and color. Therefore, recognition of live versus dead mites is commonly employed by use of an ethanol wash method to extract most mites from a plant sample.

An extensive array of related *Brevipalpus*-borne diseases has been identified in numerous ornamental plants including *Dracaena marginata* Lam., *Hibiscus*, *Hedera canariensis* Willdenow, *Pittosporum tobira* (Thunberg), *Trachelospermum asiaticum* Nakay, *Brunsfelsia uniflora* D. Don, *Cestrum*, *Malvaviscus*, *Pelargonium hortorum* L. H. Bailey, *Thunbergia erecta* T. Anders, *Salvia*, *Clerodendrum*, and many genera of the Orchidaceae (Kitajima et al. 2003; Kondo et al. 2003; Nogueira et al. 2003, 2004; and E. W. Kitajima et al., Departmento de Entomologia, Fitopatologia e Zoologia Agricola, Universidade de São Paulo, Brazil, unpublished). Both cytoplasmic and nuclear types of viruses are represented and many of these ornamental plant diseases are not known to occur within the United States. All are vectored by one or more species of *Brevipalpus* mites and the diseases must be considered as potential threats to the US ornamental industry. In addition, we do not know enough about citrus leprosis to exclude the possibility of one or more ornamental or non-citrus hosts being silent carriers of one or both viruses currently identified as citrus leprosis (Rodrigues et al. 2003). Recently, Rodrigues et al. (2005) successfully transmitted citrus leprosis (cytoplasmic type) from *Citrus sinensis* to *Solanum violaefolium* Shott (Solanaceae) using viruliferous mites (*B. phoenicis*). However, they were not successful in transmitting the virus back from *S. violaefolium* to citrus but were able to transmit the virus between plants of *S. violaefolium*.

There are several reasons for concern when we import living plant materials into the United States. They may include live and potentially virus-infected mites within the genus *Brevipalpus*. First, three *Brevipalpus* species (*B. phoenicis*, *B. obovatus* Donnadieu, and *B. californicus* (Banks)) have extensive and highly diverse host plant ranges (see Childers et al. 2003c). Second, *Brevipalpus* mite vectors are infected for life once the virus is acquired during feeding on citrus. Third, mites in this genus are long lived relative to many tetranychid species. Fourth, *Brevipalpus* populations are primarily or exclusively female. Fifth, mites in this family disperse aerially on wind currents. Proximity of citrus to numerous ornamental host plant species throughout Central America can be expected given the large rural populations of people, agrarian economies, and widespread distribution of dooryard and commercial citrus plantings as well as an abundant array of other host plants (Childers et al. 2003a, b, c). Potentially large numbers of viruliferous mites could be moved from citrus hosts in countries having citrus leprosis to non-citrus hosts including propagative ornamental hosts for export. The mites are not known to successfully transmit citrus leprosis to non-citrus hosts and back again to citrus. Rather, virus-infected mites could be physically distributed onto various plants including ornamentals via aerial dispersal. When one combines the unique characteristics of mites in this genus as described above with the huge numbers of ornamental plants being shipped, there may be significant risk for citrus leprosis being introduced into Florida on these non-citrus host plants from countries where this disease occurs. This should be of immediate concern to the citrus industries of six states (Alabama, Arizona, California, Florida, Louisiana, and Texas).

The importation of live ornamental plants into Florida from countries having citrus leprosis and numerous related diseases of ornamental plants should raise serious concerns about the potential risk in providing pathways for introduction of these diseases.

Numerous species of Tarsonemidae are recognized as plant pests (Jeppson et al. 1975; Lindquist 1986), as are species of acarid mites within the genus *Rhizoglyphus* (Diaz et al. 2000). The authors stated clearly that the systematics of the genus *Rhizoglyphus* remains in a state of confusion. Species within this genus are also important agricultural and stored product pests. Therefore, the presence of a mite in this genus should be sufficient to require the shipment to be rejected at the port. If USDA APHIS Plant Protection and Quarantine cannot presently reject such shipments then appropriate legislation should be enacted to further protect United States agriculture including the ornamental industry.

Spider mites are notorious pests and species within the genus *Tetranychus* cannot be accurately separated to species without males (Jeppson et al. 1975). If there is insufficient sample material to accurately identify the species of spider mite, then that shipment should be treated or destroyed.

The excessive number of recent pest mite introductions into the United States (Table 1) must serve as a mandate for future actions to restrict movement of exotic pests into the United States. Two recommendations are presented to USDA APHIS PPQ based on the numbers of mite infested ornamental plant shipments identified in this preliminary survey from Central American countries. First, a sampling program specifically for mite pests on all live ornamental plant shipments coming into the United States should be established. Visual inspection for mite infestations on large numbers of plants is inadequate due to time constraints of inspectors, the minute

size of mites, their distribution on the plants, cryptic coloration, and behavior.

A sampling protocol for in-coming ornamental plant shipments would include a designated subsample of plants in a shipment. Use of either an 80% ethanol wash or a specified concentration of detergent solution would be employed in combination with a filtration process to reduce the alcohol or detergent solution volume to a desired level for examination with a stereomicroscope. Use of the alcohol wash method would be preferred if the samples were to be stored before examination. Otherwise, the detergent wash method would be the preferred procedure if examination was completed immediately after processing. Certain detergent materials have a flushing or irritating reaction to various arthropods including mites. Hence, many of the mites would remain alive longer following this procedure versus the alcohol wash method.

This assessment should be done for a minimum period of one year to identify trends and seasonal patterns of different pest mite species (as well as other small arthropods) and provide assurance of compliance by foreign shippers.

We only recovered three *Brevipalpus* specimens from our limited sampling on February 6-7. Seasonal trends of this mite and others must be determined on foreign plant shipments entering the United States. Seasonal abundance trends of pest mite species are known for various agricultural crops within the United States. Such patterns of activity and population increase by many exotic pest mite species remain unknown for most ornamental plants grown in Central America and Asia.

Second, legislation is needed that would require that any shipment of ornamental plants entering the United States either as ornamental cuttings or rooted plants for propagative purposes be free of pest mites and other plant pests. This requires sub-sampling for mite species within different ornamental plant shipments other than by visual means alone. Legislation requiring the importing companies to treat their plant materials with an insecticide and acaricide prior to shipment should be enforced to protect American agriculture as well as our ornamental industries from both exotic pest mite introductions or exotic diseases that could be transmitted by one or more exotic or domestic mite species. The risk of introducing pest mite infested plants could be significantly reduced by off-shore inspection and certification of pest-free status and pre-clearance at the port of export as recommended by The National Plant Board (National Plant Board 1999) and consistent with ISPM 4, Requirements for the establishment of pest free areas (FAO, 1996).

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