

# A control strategy for breaking the virus-vector cycle of *Brevipalpus* spp. and the Rhabdovirus disease, citrus leprosis

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**ABSTRACT.** Citrus leprosis is a serious virus disease transmitted by *Brevipalpus* (Tenuipalpidae) mites that can ultimately kill citrus trees. The disease is currently found in South America and Panama and poses a threat to the citrus industries in the Caribbean, Central America, Mexico and the United States. Prior to 1926, citrus leprosis nearly destroyed the citrus industry in Florida (USA), but the disease has not been found since 1962. Alternative approaches are needed to control leprosis because elimination of the mite is not possible. Increasing chemical costs, acaricide resistance and the wide range of plant hosts exacerbate control efforts. A six step program is proposed to break the virus-vector cycle in Central America. The program includes the use of quarantine, training, education, monitoring and tree removal to identify and prevent the spread of citrus leprosis. In addition, the proposed program includes steps to take when citrus leprosis is detected in an area.

**Key words:** Citrus leprosis, Citrus, Virus, Mites, Control strategies.

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## Introduction

Citrus leprosis occurred in Florida prior to 1962 and reportedly nearly destroyed the citrus industry between 1900 and 1925 (Knorr and Price 1958, Knorr 1968). Symptoms of leprosis in Florida were reported to occur on fruit, leaves, twigs and large limbs (Fawcett and Lee 1926, Knorr and DuCharme 1950, 1951, Knorr and Price 1958, Knorr *et al.* 1968). Symptoms on large limbs are inconsistent with symptoms observed in Brazil and Panama (Kitajima *et al.* 1972, 1974, Rodrigues 2000, Chagas *et al.* 2000). Fawcett and Lee (1926) described differences between leprosis and citrus canker symptoms on leaves and twigs. A description of citrus leprosis symptoms in Florida and supportive photographs of leaves, fruit and twigs were published by Knorr and DuCharme (1950, 1951).

These symptoms were identical to leprosis symptoms found in Brazil, Argentina, Venezuela, Paraguay and Panama today.

Widespread use of wettable sulfur on Florida citrus beginning about 1923 for mite control reportedly was responsible for the disappearance of leprosis in treated citrus grove sites (Knorr *et al.* 1968). One to three thoroughly applied, high volume handgun applications of sulfur were applied per season both to the inner and outer canopy areas of each citrus tree in treated orchards. By 1948, citrus leprosis symptoms had disappeared in sulfur-treated citrus sites in Florida (Knorr *et al.* 1948). The freeze of December 1962 probably eliminated the last vestiges of the disease within the State. Leprosis-like symptoms on citrus

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leaves in Florida have been rarely observed since then. The most recently observed instance of leprosis-like symptoms on grapefruit and ‘Hamlin’ orange leaves collected from Manatee County on 29 August 1997 were subsequently found to be free of leprosis virus (Childers *et al.* unpublished data).

Potential vectors of leprosis from both Florida and Texas citrus include *Brevipalpus phoenicis* (Geijskes), *B. californicus* (Banks), and *B. obovatus* Donnadieu. All three species reportedly occur on Florida citrus while only *B. phoenicis* and *B. californicus* have been reported from Texas citrus (Dean and Maxwell 1967, Knorr *et al.* 1968, Denmark 1984, Childers 1994, French and Rakha 1994).

Chemical control of *Brevipalpus* spp. and the citrus rust mite *Phyllocoptruta oleivora* (Ashmead) on citrus in Brazil exceeds 100 million US dollars annually (Ferreira 1999). Table 1 summarizes various chemical classes of acaricides that are effective in controlling *Brevipalpus* mites on citrus. Alternative control strategies are needed due to increasing chemical production costs and problems with acaricide resistance (Omoto 2000). Citrus leprosis is a serious virus disease that can ultimately kill citrus trees (Rodrigues 2000). The disease has been restricted to South America since its disappearance from Florida prior to 1962. Severe export limitations are imposed on countries that have leprosis.

Citrus leprosis was confirmed in Panama in 1999 (Dominguez *et al.* 2001). This past year the disease was confirmed in at least 462 hectares of citrus in Potrerillos, Boquete and Volcancito areas of Chiriqui

Province, Republic of Panama and the infection is believed to be more than 5 years old. Rodrigues believes leprosis has been in Chiriqui Province for at least 10 years because 1. the disease has an initial slow spread, and 2. rapid spread of leprosis is directly related to the amount of disease available. Therefore, a low level of the disease equals a slow initial spread (Rodrigues 2000). The virus is non-systemic, occurs only in citrus, and spread only by *Brevipalpus* mites (Rodriguez *et al.* 2000). A rapid spread of this disease throughout Panama is anticipated with eventual establishment throughout the Caribbean, Central America, Mexico and ultimately the United States. Its impact on future citrus production throughout the Caribbean and Central America will be significant.

#### **Guidelines to alternative approach to breaking the virus-vector cycle**

Because the citrus industry is of substantial value, an alternative approach to breaking the virus-vector cycle is presented with the idea of providing guidelines for prompt and decisive action when a localized outbreak of leprosis occurs. Eradication of the mites is not possible.

1. Establish a total quarantine on the movement of all citrus fruit or citrus plants or cuttings from Panama or other countries infected with citrus leprosis into Costa Rica.
2. Develop a training program on the accurate identification of citrus leprosis symptomatology through the Ministry of Agriculture in Costa Rica in conjunction with the University of Costa Rica, University of São Paulo and the University of Florida. Concurrently, develop a series of color photographs to illustrate disease symptoms on ‘Valencia’, navel orange and tangerine varieties grown in Costa Rica. Accurate recognition of leaf, fruit and green wood leprosis lesions is essential.
3. Develop a comprehensive monitoring program throughout Costa Rica, especially along the border with Panama to identify early outbreaks of this disease. An initial survey should be completed to identify the distribution and locations of both commercial and dooryard citrus trees especially in a band 5-20 kilometers along the eastern border of Costa Rica. Periodic inspections of this area should be pursued more intensively compared with areas west and north of this zone.
4. An intensive educational program must be implemented to develop and encourage local support from dooryard growers and commercial

**Table 1.** Acaricidal activity against *Brevipalpus* spp.

<b>Class of acaricides</b>	<b>Tenuipalpidae</b>
Petroleum oil	?
Sulfur	Yes
Chlorinated Hydrocarbons (dicofol, endosulfan, chlorobenzilate)	Yes
Pyrethroid (fenpropathrin)	No
Carboximide (hexythiazox)	Yes
Tetrazine (clofentezine)	?
Carbonitrile (pyrrol)	Yes
Organophosphates (ethion, dimethoate, methidathion)	No
Carbamates (aldicarb, carbaryl)	Yes/No
Organotin (fenbutatin oxide)	Yes
Sulfite Ester (propargite)	Yes
Macrocyclic Lactone (abamectin)	No/?
IGR (dimilin)	No
Pyridazinone (pyridaben)	Yes

operations. Establish a media campaign (television, radio, extension meetings, meetings with various church and other local political organizations, schools, as well as direct letter and poster notifications) to educate landowners, growers and the local populace about the disease, the vectors and the ultimate need for destruction of infected trees. Not only must the populace become educated about this disease, they must also become involved and active participants such as in the screwworm program. Citrus leprosis in Central America will effectively eliminate dooryard production of oranges and tangerines in areas where leprosis becomes established because of their known susceptibility to the virus. For commercial operations, multiple acaricide applications will be required annually to maintain suppression of viruliferous mites.

5. Define and establish a minimum 1 km buffer zone (outer perimeter) around each infected area as soon as it is identified. Begin spraying citrus trees from the outer perimeter edges inward and move towards the center of infection. The purpose of spraying an acaricide is to substantially reduce motile populations of *Brevipalpus* mites and reduce the potential for further distribution of infected mites by the eradication crews. Spray commercial grove sites using high volume/medium pressure spray equipment (tractor-drawn 1,000 to 2,000 liter capacity tanks) or high volume airblast sprayer equipment (i.e. 2,000 to 2,500 L/ha). Only use backpack ulv (ultra low volume) sprayers (5-8 L/tree) in dooryard or hillside conditions not accessed with larger equipment. It is imperative that thorough coverage of the infected plants is achieved. Convective movement of spray can easily occur with moderate temperatures and windy conditions. When using ulv equipment one must be aware of this phenomenon.

Within 24 hours following acaricidal treatment, cut the treated trees and immediately burn them. Immediately following tree removal, paint each exposed tree stump with an appropriate registered herbicide using an extended handled brush. Many herbicides can be dangerous to applicators and cause severe eye and/or skin irritation as well as dermal or inhalation toxicities. Substantial care must be provided for the safety of the applicators including provision of a respirator, protective clothing and gloves when using any herbicide. Also,

provisions must be taken for the protection and safety of the residents around treated areas. In addition, extreme caution must be taken when using herbicides to avoid phytotoxicity of adjacent plants in dooryard situations.

6. Develop a payment or citrus tree replacement program to dooryard citrus owners to assure their support in the area-wide effort.

#### **Research needs for *Brevipalpus* vectors of leprosis and related virus-like diseases**

Most taxonomic specialists have reported morphological variation between different populations of *B. phoenicis*, *B. californicus*, and *B. obovatus* (Gonzales 1975, Smith Meyer 1979, Baker and Tuttle 1987, Evans *et al.* 1993, Ochoa *et al.* 1994). Possible species complexes are suspected. *Brevipalpus* mites from citrus in Panama were collected in July 2000 by the senior author. The mites were identified as *B. phoenicis* by Dr. Ronald Ochoa, USDA ARS Systematic Entomology Laboratory in Beltsville, Maryland. He found distinct morphological differences among the specimens examined.

A basic question needs to be resolved regarding the presence of one or more species of *Brevipalpus* on citrus. We need to know if there are one, two or several species of *Brevipalpus* involved in the transmission of citrus leprosis and other related viruses of coffee, passion fruit and various ornamental plants. If different *Brevipalpus* species are present, then what are their host ranges? Alternative control strategies cannot be effectively developed until these questions are resolved. Molecular techniques are needed to evaluate populations of mites collected from citrus, coffee and other crops in South, Central and North America. Results from these studies will provide further data to the mite taxonomists in evaluating a possible species complex within or between populations of *Brevipalpus* mites from different regions and/or commodities. Confirmation of host plant data would be included. Results are needed to address possible control approaches such as breaking the virus-vector cycle in a particular area of Costa Rica or another area within Central or South America. Additional research is needed to clarify differences between *Brevipalpus* feeding injury and citrus leprosis virus symptoms in citrus (Childers 1994). The development of efficient molecular and/or serological tools for characterization and identification of virus are also needed.

Provided that current taxonomic and host range data for *B. phoenicis* are correct, then risk of citrus leprosis spreading throughout Central and North America is high. Several factors must be considered with regard to the mite vector and its movement. First, longevity of *Brevipalpus* species from larval through adult longevity can exceed 40-60 days. Second, once the mite is infected with leprosis it can transmit the disease for the remainder of its life. Third, species found on citrus are difficult to remove from fruit because of their tendencies to favor blemished areas on the rind or to locate beneath the sepals. Fourth, many phytophagous mite species disperse aerially. If current host range data are

correct, then viruliferous mites could be moved on one or more woody ornamentals or other non-citrus hosts occurring in proximity to infected citrus plants from Panama or another country with the disease to other Central American or Caribbean countries and eventually to Mexico and the United States. This combination of factors should be considered relative to their potential in spreading the disease from countries with citrus leprosis.

#### Endnote

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