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Banana bunchy top virus and its vector *Pentalonia nigronervosa* (Hemiptera: Aphididae)[1]

Susan E. Halbert[2] and Carlye A. Baker[3]

INTRODUCTION: Banana bunchy top disease (BBT) is one of the most serious diseases of banana. It stunts the plants and reduces yield severely. The disease is caused by *Banana bunchy top virus* (BBTV), which is transmitted by banana aphids (*Pentalonia nigronervosa* Coquerel). The aphids occur widely in Florida, but the pathogen has not been reported in the Western Hemisphere.

In Florida, there is little commercial banana production, but dooryard plantings occur as far north as Gainesville. Bananas are propagated vegetatively, except for a few ornamental cultivars. Thus, systemic pathogens such as viruses are propagated with the crop. Florida is a high-risk location for exotic introductions of insects and pathogens that arrive with planting material, including BBTV. Even though there would be little commercial consequence in Florida to the introduction of BBTV, there are few barriers to prevent the disease from spreading into commercial production regions in the Caribbean, South, and Central America, once it reaches Florida. Fortunately, strict regulatory measures can be used to control the disease (Ploetz et al. 2003).

DESCRIPTION: Symptoms of BBT are relatively easy to recognize. As the name implies, severely affected plants produce small, erect, bunched leaves (Fig. 1). Leaf margins are yellowed and turn necrotic. Infected plants rarely produce a bunch, but if they do, the fruit stalk is small and distorted (Ferreira et al. 1997; Ploetz et al. 2003; Nelson 2004). Initial leaf symptoms are more subtle. The disease produces a monocot mosaic often referred to as "Morse code" streaking because of the irregular pattern of dots and dashes along the leaf veins (Fig. 2). Another symptom is known as "J-hooking." This symptom can be seen as dark green hooked lines in the normally pale part of the leaf next to the midrib (Ferreira et al. 1997; Nelson 2004) (Figs. 2 - 4). The "dark streaks along the secondary veins on the underside of the lower portion of the leaf-blade, the leaf stalk, or the lower part of the midrib" are the first symptoms that show up (Magee 1927).

Pathogen: The virus that causes BBT is a small, isometric, non-enveloped virus about 18-19 mm in diameter. It is a multipartite single-stranded DNA virus (Xie and Hu 1995) and the type member of the virus genus Babuvirus, which is one of two genera in the family Nanovirideae (Association of Applied Biologists 2013, Burnt et al. 1996). BBTV can be diagnosed by the distinctive symptoms it causes in an infected banana and by serological and/or PCR lab tests. Any banana plants suspected of being infected with this virus should be sent to the Florida Department of Agriculture and Consumer Services, Division of Plant Industry to be tested.

Aphid vectors: The aphid vectors occur nearly everywhere bananas are grown (Figs. 5-7). They are cryptic, living behind the leaf sheaths in wet environments (Fig. 7). They do not move much when disturbed, so it is easy to mistake the dark aphids for dark spots that often occur on the pseudostem under leaf sheaths.

Foottit et al. (2010) separated *P. nigronervosa* from *Pentalonia caladii* van der Goot. The two species, described from Réunion and Java, respectively, are similar morphologically and had been synonymized. Foottit et al. (2010) found that the length of the ultimate rostral segment (urs; a conservative and useful character in aphid taxonomy) and the host preferences will separate the two species. In nature, *P. nigronervosa* feeds almost exclusively on Musaceae, whereas *P. caladii* feeds on Zingiberaceae, Araceae, and Heliconiaceae. This taxonomic change agrees with the findings of Robson et al. (2007) that *P. nigronervosa* laboratory cultures performed poorly on ginger and taro. If the aphids in the genus *Pentalonia* are found on plants in nature, it usually is safe to assume that if the plant is a banana, the aphid is *P. nigronervosa*, and if the plant is not a banana, the aphid is *P. caladii*. For trapped specimens, it is necessary to measure the urs to determine the species. If the urs is < 0.13mm, the species is *P. caladii*, and if it is >0.13mm, the species is *P. nigronervosa*. Both *P. nigronervosa* and *P. caladii* occur in Florida. Two other obscure species in the genus *Pentalonia* have been described from Australasia. See the discussion in Foottit et al. (2010) for separation of those species, which do not occur in Florida.

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[1] Contribution No. 1287, Bureau of Entomology, Nematology, and Plant Pathology - Entomology Section.

[2] Taxonomic Entomologist, FDACS, Division of Plant Industry, P.O. Box 147100, Gainesville FL 32614-7100.
[3] Virologist, FDACS, Division of Plant Industry, P.O. Box 147100, Gainesville, FL 32614-7100

In trap samples, alate *Pentalonia* species look quite similar to alate *Picturaphis* spp., the latter being pests of legumes in the Neotropics. Alate aphids in these genera can be separated by the rhinaria on the antennae. *Pentalonia* species have secondary rhinaria on the fourth and fifth antennal segments, whereas *Picturaphis* species do not (Voegtlin et al. 2003). *Picturaphis* does not occur in the state of Florida. Earlier reports of *Picturaphis brasiliensis* (Moreira) in Florida are the result of mistaking "Florida, Puerto Rico" (a municipality in Puerto Rico) for the state of Florida (Foottit et al. 2006).

LIFE HISTORY: BBTV is propagated easily via vegetative propagation of the crop. Long distance spread occurs by transport of infected propagative materials. Since bananas normally are propagated vegetatively, risk of introduction of the pathogens in infected planting material is high. Additionally, there are cultivars of bananas that manifest mild or no symptoms. These cultivars are particularly risky in terms of pathogen introduction.

The banana aphid, *P. nigronervosa*, transmits BBTV in a persistent, non-propagative manner. The virus is restricted to the phloem (Magee 1927), which means that for practical purposes, only colonizing aphids are able to transmit the pathogen. There is no transovarial transmission to aphid offspring (Hu et al. 1996). Hu et al. (1996) found a minimum acquisition period of 4 hr and a minimum inoculation period of 15 min. The banana aphid is an efficient vector, in that single aphids transmitted BBTV at up to 67% efficiency. Transmission rates increased with longer acquisition and inoculation periods (Hu et al. 1996).

Pentalonia caladii has been shown to be able to transmit BBTV (Watanabe et al. 2013). However, since there is little natural overlap of the two *Pentalonia* species on banana, the ecological relevance of possible reservoirs of BBTV in plants outside the Musaceae could be minimal except in eradication situations where complete elimination of the virus from the eradication area is necessary.

DISTRIBUTION: BBT was noticed for the first time in Fiji in 1891 (Magee 1927). Currently, it is found in a number of Pacific islands including Hawaii, Southeast/South Asia. It also has been reported from Central Africa (12 countries) (Blomme et al. 2013), Eritrea (Blomme et al. 2013), and Egypt (Blomme et al. 2013; Ploetz et al. 2003). So far, there is no evidence that the disease occurs in the Western Hemisphere.

HOSTS: BBTV has been detected in many cultivars of edible bananas, with varying susceptibility. Reports outside of the Musaceae have not been corroborated (Hu et al. 1996, Ploetz et al. 2003; Watanabe et al. 2013). Given what is known now about the aphid host preferences, potential ornamental hosts might not be important in endemic situations, but further investigation is needed for purposes of eradication.

SURVEY AND DETECTION: Look for plants with typical bunchy appearance. Check leaves for "Morse code" streaking on the leaf blades and "J-hooks" near the mid-veins.

CONTROL: Strict regulatory measures are necessary for control, management or eradication of BBT. Banana aphids do not fly very far (Magee 1927; Ploetz et al. 2003). Nearly 2/3 of naturally occurring new infections are less than 20 m from an infected source plant (Allen 1978). The first symptoms show up (incubation period) in 23-29 days (Magee 1927). The latent period (time from infection to the time when the virus is accessible to other aphids) is the time it takes for 3.7 new leaves to emerge (Allen 1987). Magee (1927, 1936) proposed the following measures for management of the disease: registration of all banana plantations, establishment of quarantine zones, restrictions on the movement and use of planting material, regular inspections of all banana plantations for BBT, ongoing education and extension programs for growers, and prompt destruction of all infected plants. When eradicating plants, it is necessary to kill the aphids first, and then kill the plant (Ferreira et al. 1997). Allen (1987) determined that removal of healthy plants within 5 m of an infected plant did not reduce risk to neighboring farms or have any effect on the numbers of new infections. It is important to time inspections using the 3.7 leaf rule for early detection of symptoms (Allen 1987). These measures enabled complete rehabilitation of the Australian banana industry after production had collapsed completely as a result of establishment of the disease in the 1920s (Magee 1936; Ploetz et al. 2007).

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Fig. 1. Typical bunchy top symptoms (Photography credit: Susan E. Halbert, FDACS, DPI).

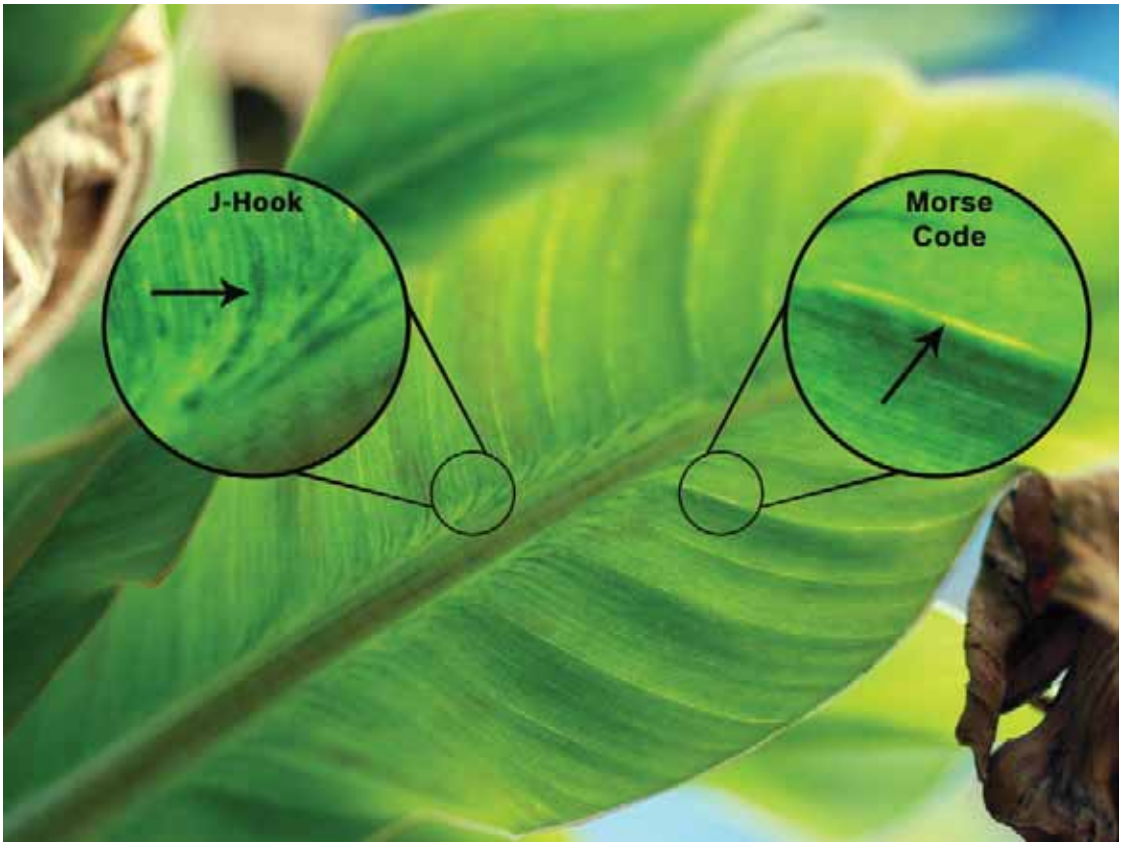

Fig. 2. "Morse code" streaking and "J hook" symptoms (Photography credit: John S. Hu, University of Hawaii at Minoa).

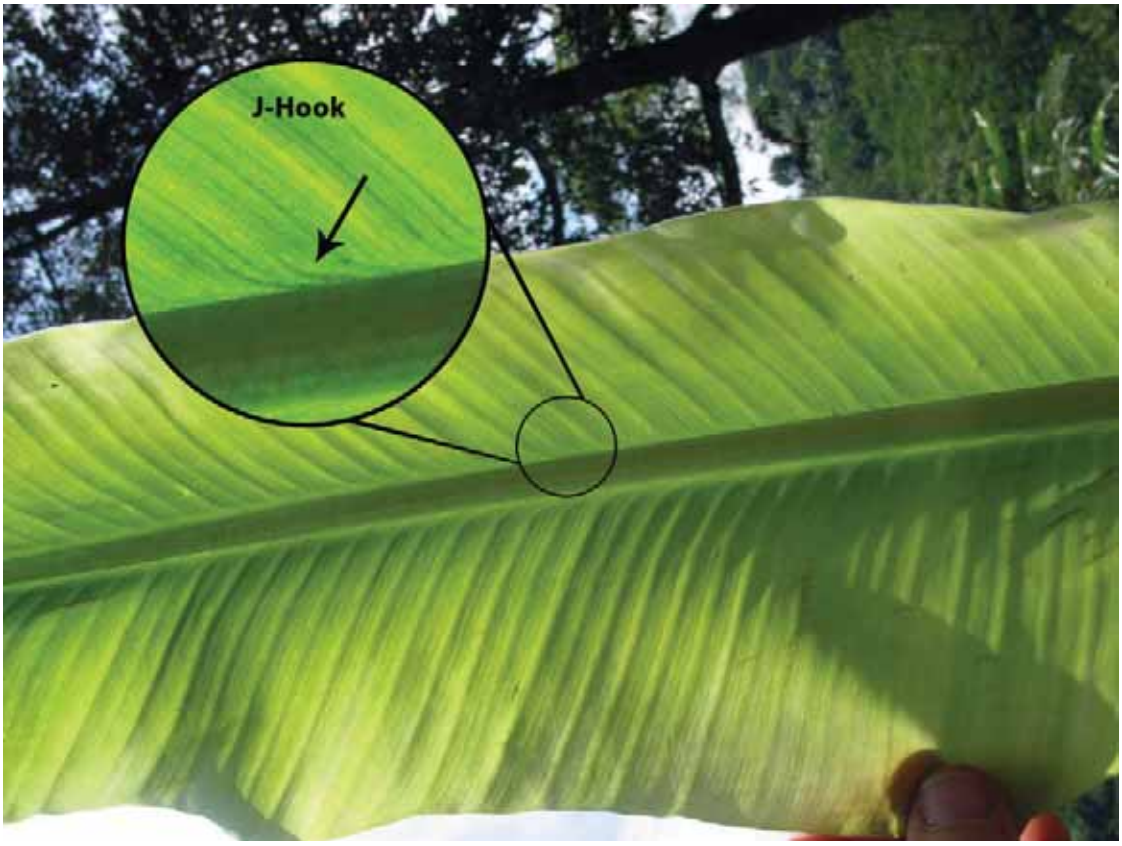

Fig. 3. "J hook" symptoms (Photography credit: Susan E. Halbert, FDACS, DPI).

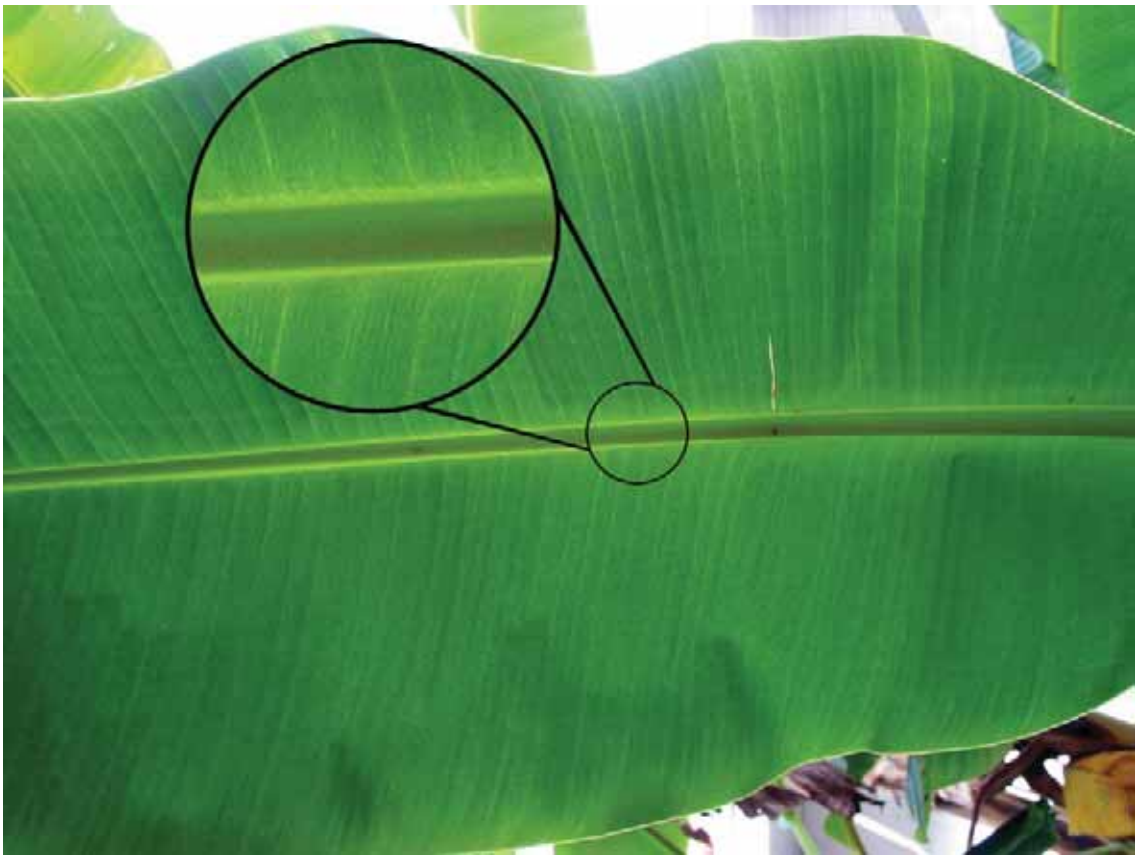

Fig. 4. Healthy banana leaf (Photography credit: Susan E. Halbert, FDACS, DPI).

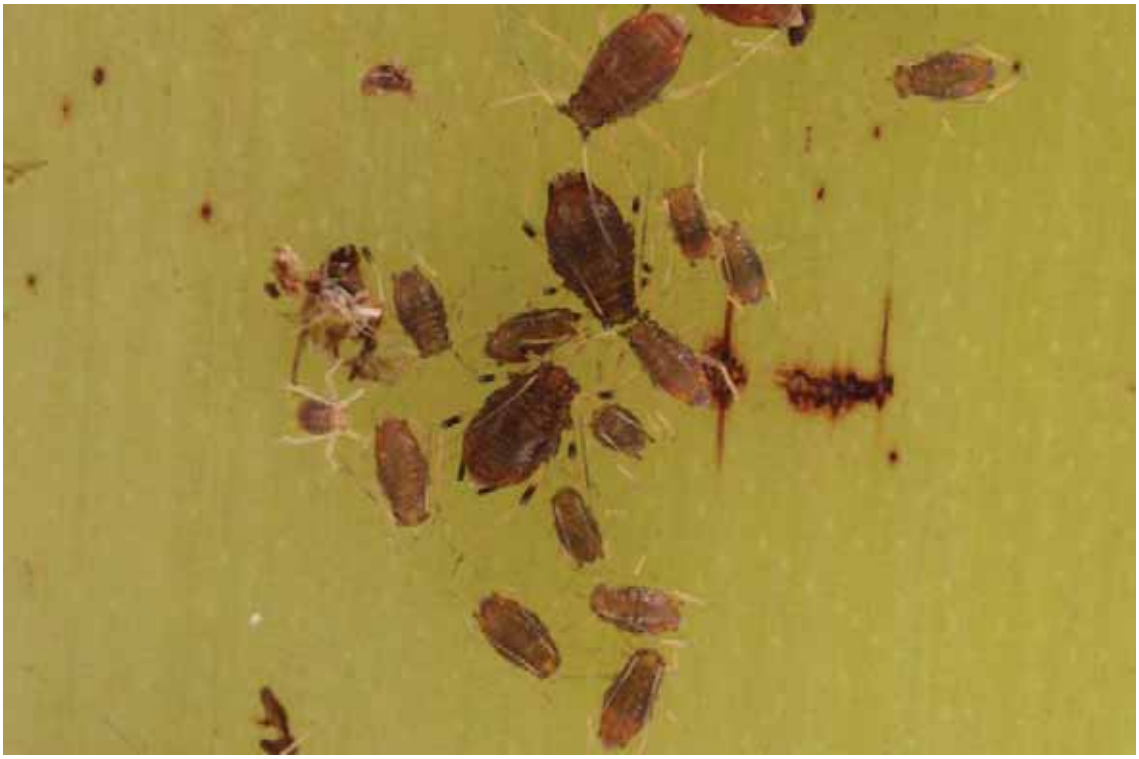

Fig. 5. Banana aphids, *Pentalonia nigronervosa* Coquerel (Photography credit: Lyle J. Buss, University of Florida).

Fig. 6. Banana aphids, *Pentalonia nigronervosa* Coquerel (Photography credit: Lyle J. Buss, University of Florida).

Fig. 7. Banana aphid colony, *Pentalonia nigronervosa* Coquerel. Note that the aphids are well camouflaged in the wet environment behind the leaf sheaths. (Photography credit: Susan E. Halbert, FDACS, DPI).