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FLAGELLATED PROTOZOA, THREATENING NEW PLANT PATHOGENS FROM SOUTH AMERICA[1]

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Abstract. **Several recently described lethal diseases of coconut and African oil palms in South America and the Caribbean have been found to be associated with trypanosomes. These fastidious, phloem inhabiting protozoa are readily observed at 400X under phase contrast illumination in juice expressed from root, bud, or inflorescence tissue of infected palms. Infected palms exhibit inflorescense necrosis, rapid dieback of foliage, and extensive root loss. Death ensues some 2 mo. after initial symptom expression. These diseases have been reported from Surinam, Colombia, Ecuador and Peru in South America, and from Trinidad in the Caribbean. No controls are known. The lethal yellowing resistant 'Malayan Dwarf' coconut is susceptible to these organisms, thereby posing a threat to Florida and other areas where extensive replantings have been made.**

Recently, protozoa of the genus *Phytomonas* (Trypanosomatidae) have been implicated as causal agents of several lethal diseases of coconut palms (*Cocos nucifera* L.) and African oil palms (*Eleais gnineensis* L.) in South America and islands of the southern Caribbean. The first report, by Parthasarathy *et al.* (14) in 1976, recorded the occurrence of these flagellated organisms in the phloem of hartrot diseased coconut palms in Surinam. Subsequently, Dollet *et al.* (1) reported the occurrence of *Phytomonas* in the phloem of sudden wilt diseased African oil palms in Peru, and in 1978 Waters reported flagellates in dying coconut palms in Trinidad (21). By 1979, *Phytomonas* was reported from dying oil palms in Ecuador (17) and coconut and oil palms in Ecuador (2) and Colombia (2, 6, 8).

Confusion exists regarding the disease in Trinidad which has occasionally been referred to as bronze leaf wilt. Griffith has clarified this matter, showing that bronze leaf wilt, as previously described in the literature, is of physiological origin, occurring only in the dry season in palms grown on hardpan soils (3). Griffith has given the flagellate disease of coconut in Trinidad the name Cedros wilt, after the town where the disease was first described.

The concept of protozoal plant pathogens is not new; Stahel reported flagellates in hyperplastic phloem of wilt diseased coffee plants (*Coffea liberica* Bull. ex Hiern.) in 1931 (16) and his report was verified by Vermulin in 1963 and 1967 (19, 20). However, these reports were largely overlooked by plant pathologists, even though wilt (phloem necrosis) has essentially limited coffee production in Surinam for years. The coffee flagellate, *P. leptovasorum* Stahel was consistantly associated with diseased plants and was graft transmissable. No natural form of transmission was found and the flagellate was not amenable to axenic culture, so that Kochs' postulates were not fulfilled. However, *P. leptovasorum* remains the only likely pathogen for the coffee disease.

The hartrot flagellate from Surinam was collected by McGhee and McGhee and in 1980 they gave it the specific epithet *P. staheli* on the basis of morphological differences from other members of the genus *Phytomonas* (12). Flagellates from three unique palm diseases in Colombia were examined by McCoy and Martinez-Lopez (9) and on the basis of morphology, all were classified as *P. staheli*. Specific measurements of palm flagellates from other areas are not available, however, it is probable that they will fall within the range of *P. staheli* as well.

This paper summarizes the hosts, localities, and disease syndromes in which flagellated protozoa have been found, and assesses the potential for further spread of these diseases.

Host List of Phytomonas

Coffee—Stahel (16) and Vermulin (19, 20) reported the presence of *P. leptovasorum* in wilt diseased *Coffea liberica* in Surinam. The flagellates were present in living sieve elements of hyperplastic phloem prior to death of the plants. Highest concentrations of organisms occurred in root and stem tissues showing hyperplastic division of the cambium producing numerous abnormal sieve elements. The flagellates were transmitted through grafts using roots as scion material. Symptoms consisted of foliar yellowing and defoliation along with a firm attachment of the bark to the xylem cylinder. In acute infections, death of the tree occurred in 2 to 6 weeks. In chronic infections, the decline took about 1 year. Attempts at culture of *P. leptovasorum* using a broad range of culture media failed, flagellates could be maintained alive for no more than 6 hours (20). The disease was reported to exist in Surinam, Guiana, Brazil, and Colombia (16, 19).

Coconut Palm—The hartrot disease of coconut palms in Surinam has symptoms very similar to those of lethal yellowing (LY) and, at first, the disease was thought to be LY. However, when tissue samples of hartrot affected trees were sent to M.V. Parthasarathy for electron microscopic examination, he found flagellated protozoa in the phloem rather than the mycoplasmalike organisms expected for LY (14). Liquid squeezed from living root, bud, and inflorescence samples collected in the field and examined at 400X in the light microscope after either staining with giemsa, or observing fresh with phase contrast optics, was seen to contain numerous flagellates (12, 15). Like LY, the symptoms of hartrot include inflorescence necrosis, shelling of immature fruit, dieback of leaves progressing from oldest to youngest, and bud and root necrosis.

A vector of hartrot disease has not been found. McCoy and Martinez (9) suggested that phloem feeding homoptera should be investigated since the flagellates are phloem inhabitors. Griffith has suggested that the milkweed bug *Oncopeltus cingulifer* Stal. can acquire Phytomonas from infected milkweed, *Asclepias curisavica* L., and carry it to palms where the bug is occasionally found (3). He further presented evidence that the pentatomid *Mecistorhinus picea* Palisot de Beauvois is responsible for palm to palm spread of *Phytomonas*. *Phytomonas elmasiani* readily infects both milkweed and *O. cingulifer* which serves as a vector. It remains to be verified if the Phytomonas in palms is *P. elmasiani*, however.

African Oil Palm—Shortly after the report of flagellates occurring in coconut palm in Surinam, flagellates were reported from African oil palms affected by sudden wilt disease in Peru, Ecuador, Colombia and Surinam (1, 2, 17,

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18). The symptoms of sudden wilt include foliar browning and desication beginning in the lowest fronds and extending from frond tip to frond base. All fruit aborts and rots and root necrosis occurs. Only mature, bearing palms of 5 or more years of age have been seen to be affected by sudden wilt.

Interestingly, another disease of African oil palm, case nine, is also associated with flagellates. This disease, which occurs in the Magdalena Valley of Colombia, affects only non-bearing palms under 3 years of age. Adjacent mature palms are not affected. In case nine, foliar discoloration begins in the center of individual leaves. Spear leaf and root necrosis occur before all leaves turn brown.

Latex flagellates—Phytomonas was first described in the latex of *Euphorbia* plants in Africa (5). The flagellate *P. davidi* occurs only in laticifers of various *Euphorbia* species and does not cause symptoms. Another flagellate, *P. elmassiani,* infects the latex tubes of *Ascelepias* and, like *P. davidi,* infections are not associated with any pathogenic syndrome (4, 11). These two flagellates are distinguished from one another by difference in size (10).

Description of Flagellates—Flagellates collected from palms are all elongated promastigotes of ca. 15-20 x 0.5-1.0 μm in size. Their overall structure is typical of the genus *Phytomonas.* A single flagellum is attached to the anterior end of the *Phytomonas* cell. A kinetoplast (mitochondrion) is situated at the base of the flagellum and anterior to the nucleus. Not all sieve elements contain flagellates and the numbers of flagellates are seen to vary among infected cells.

Discussion

Epidemiological studies of hartrot and sudden wilt are lacking or in doubt. In one instance a disease termed sudden wilt destroyed 5000 Ha of a 7,000 Ha plantation in Colombia (13). Control of insects and grassy weeds led to greatly reduced incidence at this site. At this site the planthopper *Myndus crudus* Van Duzee was implicated as a vector (13). However the etiological agent of that outbreak was never firmly identified. In Trinidad, Cedros wilt (hartrot) flares up occasionally and then subsides (3). Over 5000 coconut palms were killed near Cedros in Trinidad in a 2 year period from 1970-1972 (3). By 1979-1980 the disease had declined and few cases were seen.

The fact that 'Malayan Dwarf' type coconut palms are susceptible to *P. staheli* infection is of serious concern to areas affected by lethal yellowing disease. The 'Malayan Dwarf' is the principle cultivar resistant to lethal yellowing and has been extensively replanted in Jamaica and Florida. Stringent enforcement of quarantines must be maintained to insure that the hartrot agent does not get into Florida or the central and northern islands of the West Indies. Future research on the plant diseases associated with Phytomonas should concentrate on confirmation of a vector, on culture of the phytomonads (7), and on potential control measures in addition to eradication and quarantine..

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