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Raoiella indica (Prostigmata: Tenuipalpidae): The Red Palm Mite: A Potential Invasive Pest of Palms and Bananas and Other Tropical Crops of Florida[1]

J. E. Peña, C. M. Mannion, F. W. Howard and M. A. Hoy[2]

The red palm mite, *Raoiella indica* Hirst, also known as the coconut mite (A species of eriophyid mite, *Aceria guerreronis* Keifer, is also known by the common name coconut mite. It is a serious pest of the fruits (coconuts) of the coconut palm in many countries in the tropics of the Eastern and Western hemispheres.), coconut red mite, red date palm mite, leaflet false spider mite, frond crimsom mite, or scarlet mite, is an important pest of coconuts, date palms and other palm species, as well as a pest of bananas, beans, and durian in different parts of the world. Previous to its arrival in the New World, the mite was found in India, Philippines, Mauritius, Reunion, Malaysia, Israel and Egypt. *Raoiella indica* was found in Martinique and St. Lucia in 2004. During 2005, the mite was found in Dominica and during 2006 on the islands of Trinidad and Tobago, Guadeloupe, and Saint Martin (Kane et al., 2005; Etienne and Fletchmann, 2006). Kane and Ochoa (2006) reported widespread distribution of *R. indica* throughout St. Lucia on coconuts, observing that most of the lower leaves had high infestations ranging from 20-300 individuals. During 2005, *R. indica* was found infesting bananas on the island of Dominica (N. Commodore, pers. obs.). During 2006, Etienne and Fletchmann (2006) found *R. indica* infesting palms, banana, ginger, bird of paradise and other plants within the Musaceae (Table 1).

Damage

Young coconut palms appear to be the most severely injured. *Raoiella indica* lives on abaxial (lower) surfaces (Jepson et al., 1975; Etienne and Fletchmann, 2006) of coconut leaves where the eggs are deposited in colonies ranging in number from 110 to 330. In Saint Lucia, Kane and Ochoa (2006) observed that in coconuts, mite populations were on the underside of the leaflets, with a higher number on the lower leaves. Mites are located in groups ranging in number from 20 to 300 individuals (eggs, larvae, protonymphs and deutonymphs). There are no data regarding within-plant distribution in other host plants.

Extensive yellowing of lower leaves may be symptomatic of either red palm mite feeding, or any of several pests or diseases of palms and other arborescent monocots. For example, red palm mite

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2. J. E. Peña and C. M. Mannion, Tropical Research and Education Center, Homestead, F. W. Howard, Fort Lauderdale Research and Education Center, Ft. Lauderdale, and M. A. Hoy, Department of Entomology, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

damage has sometimes been misdiagnosed in the field as lethal yellowing (LY), a highly prevalent disease of palms in southern Florida and various countries of the Caribbean Basin. Like the effects of red palm mite feeding, LY infection results in extensive chlorosis of the lower leaves. However, in a very early stage of LY disease, the emerging inflorescences become distorted and the male flowers, normally of an ivory, yellow, or orange color depending on variety, turn to the color of coffee grounds, and the coconuts of all stages of development drop from the tree. Of course, a key symptom that distinguishes red palm mite damage from LY is the presence of dense populations of a red mite visible with the naked eye on the abaxial surfaces of older foliage. The exuviae (cuticle tissue discarded at molting) of red palm mites may be present as scaly patches on the leaf surface.

Figure 1. Coconut palm frond showing chlorosis and necrosis of the pinnae, Dominica. Credits: J. Pena, University of Florida

Description of Stages

Males and females were described by Sayed (1942). Adult female red palm mites are red, typically with dark patches on the body, and about 0.32 mm long. Males are smaller than females and triangular in form. Dorsal setae are present on both sexes. The body of the red palm mite does not have a striae. The first pair of dorsocentral hysterosomal setae is longer than the others; the fourth pair of dorsosublateral setae is shorter than the first pair. All dorsal body setae are slightly clublike and serrate. The larvae are reddish and sluggish. The minute eggs (0.09 mm x 0.12 mm) are oblong smooth and red and

Figure 2. Chlorosis and necrosis of pinnae appears to be more pronounced on basal fronds of coconut palms in the island of Dominica. Credits: J. E. Pena, University of Florida

Figure 3. Detail of chlorosis and necrosis on coconut fronds, Dominica, 2005. Credits: J. E. Pena, University of Florida

attached to the abaxial leaf surface by a slender stalk in patches of 100-300 eggs (Welbourne 2006).

Life Cycle

The biology of *R. indica* was studied in India by Nagesha-Chandra and Channabasavanna. (1984). Under laboratory conditions, at temperatures between 24-26°C and 60% RH, females completed their development in 24.5 days and males in 20.6 days; adult longevity was 50.9 days for females and 21.6 days for males. Fertilized females produced an average of 22 eggs and virgin females 18.4 eggs. In Mauritius, the preoviposition period is 3 days in summer and 7 days during the winter (Jepson et al., 1975). Females lay an average of 2 eggs per day over an average oviposition period of 27 days for a total of

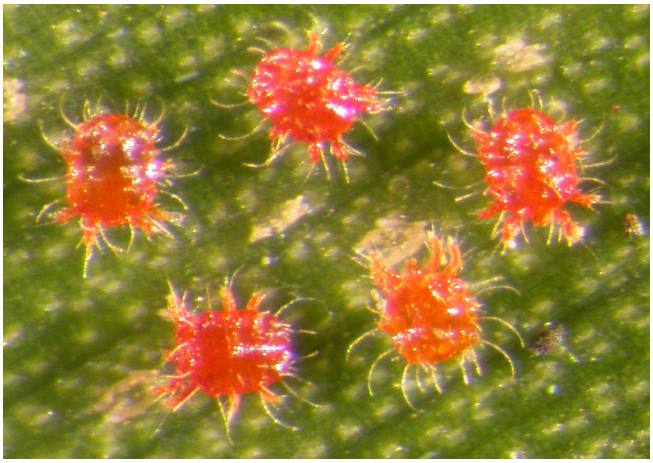

Figure 4. Females of *R. indica* on the underside of a palm frond. Credits: R. Duncan

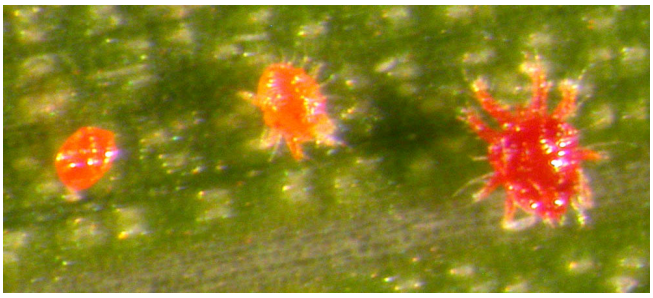

Figure 5. Male (right) and immatures of *R. indica* (egg on left; larva in middle). Credits: R. Duncan

about 50 eggs per female. The time for development of each life stage is: egg, 6.1-6.5 days; larva, 5.7-9.5 days; protonymph, 5.4-6.5 days; and deutonymph 4.1-10.5 days. The time required to complete the life cycle is 21-33 days (Zaher et al., 1969; Jepson et al., 1975). Developmental ranges are influenced by temperature, RH and host plant (Zaher et al, 1969; Gerson et al., 1983).

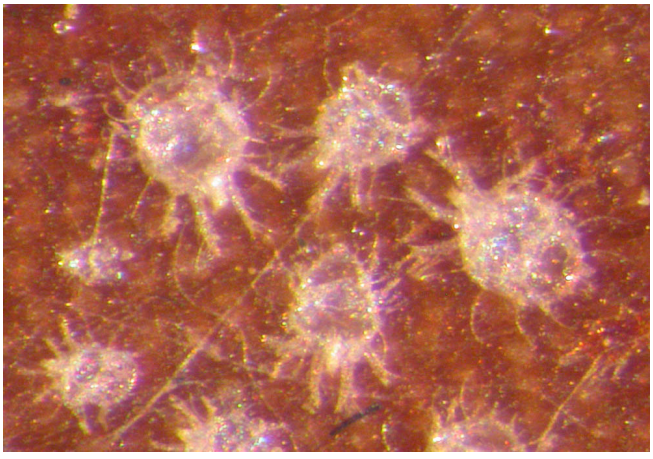

Figure 6. Skin casts left by mites attached to the surface of the adaxial surface of the leaf. These casts are regularly found close to the mid vein. Credits: R. Duncan

Seasonality

These mites are generally abundant in Mauritius on coconut from September to March, except when heavy rains occur during November and January. Starting in April, there is normally a decline in populations, which continues through August (Moutia 1958). In the summer the plants appear sickly and yellowish, a condition that may be the combined result of mite feeding and dry season conditions (Jepson et al., 1975). Howard et al. (2001) cite Sakar and Somchoudhury (1989) indicating that population build up is positively correlated with leaf moisture, crude protein and nitrogen levels in leaves in different coconut varieties.

Dispersal

Welbourn (2006) indicates that *R. indica* disperses by wind currents and transport of infested plants or leaves. Kane and Ochoa (2006) emphasize that dispersal could happen in the female stage. Mendonca et al. (2005) state that one of the most common ways of dispersal is through human activity in tourist areas where persons will come in contact with ornamental palms.

Host Plants

The current list of host plants of *R. indica* (Appendix 1) indicates that it is mostly found in palms followed by plants within the Musaceae and Zingiberaceae (Welbourn, 2006; Etienne and Fletchman, 2006). Inspection of several plants (Citrus spp., caladium, dracaena, periwinkle, tropical almond) located under infested coconuts in Trinidad showed that sometimes females fall onto these plants, but no eggs or immatures appear to develop on them (Peña, pers. obs.).

Chemical Control

Chemical applications are used in occasions of high density of the mite when it is affecting date palm in the UAE (Gassouma, 2005). In India, the application of neem oil sprays mixed with sulfur after a thorough cleaning of the coconut crown showed good results. The extract is sprayed from above, 5 to 6 times per year, and is possible with a sprayer-head attached to a long pole. The application of neem

Figure 7. Banana leaf showing signs of infestation by the red palm mite, Trinidad, 2006. Credits: J. Pena, University of Florida

Figure 8. Damage to banana; chlorosis of the leaf edge (A) followed by necrosis; necrosis is uniform on the leaf edge. Credits: J. Pena, University of Florida

resulted in a yield increase of 25%. Saradamma (1972) determined that there was a decrease in mite density 14 days after application of parathion followed by an increase of the mite population. Nadarajan et al (1990) reported that several systemic insecticides exhibited toxicity to the larvae, nymphs and adults. Phosphamidon was considered slightly superior to monocrotophos, dimethoate, formothion and demeton-methyl. However, most of these products are not registered to be used in coconuts or bananas in Florida or Puerto Rico. Current knowledge of the effectiveness of chemical control of the red palm mite is based entirely on research in India and the Near East. The methods developed in that research would not be applicable to plantation or landscape situations in the Caribbean or Florida.

(Etienne and Fletchman, 2006; Jalaluddin and Mohanasundaram, 1990; Jayaraj et al., 1991).

Chemical control of other Tenuipalpidae in crops such as citrus have shown that, in combination with petroleoum oil, pyridaben, fenbutatin-oxide, dicofol or high rates of sulfur provided at least 35 days of control (Childers, 1994). Reisi et al. (2004) observed that abamectin and emamectin can be used to control larvae, nymphs and adults of *Brevipalpus phoenicis*. However, abamectin was found to be slightly and moderately noxious to predacious mites, while emamectin was shown to be innocuous and slightly noxious to phytoseiids.

Natural Enemies

In India, during a survey for the indigenous predators, several predators were discovered preying on *R. indica.* The phytoseiid mite, *Amblyseius channabasavanni* and lady beetle, *Stethorus keralicus* Kapur (Coleoptera: Coccinellidae) were considered to be the most important predatory species (Daniel 1981). Puttaswamy and Rangaswamy (1976) cite *S. kerlaicus* feeding throughout the year on *R. indica* infesting coconut and areca palms in India. In the UAE, Gassouma (2005) indicates that there is natural control for the scarlet mite, but the author does not report the names of the natural enemies responsible for this type of control. The biology and habits of *A. channabasavanni* were determined by Daniel (1981), who found that *A. channabasavanni* females effectively consumed eggs and females of *R. indica*. Alternate food sources in the field included *Tetranychus fijiensis*, eggs and crawlers of scale insects and mealybugs that infest arecanut leaves. The field population of the predator was highest during May through June when *R. indica* populations were at their peak..

Moutia (1958) observed that in Mauritius the principal predator of *R. indica* in coconut plantations was *Typhlodromus caudatus* Chant (*Amblyseius caudatus* Berlese). The life cycle of this mite within a range of temperatures from 18° to 24.3°C required 15 to 6 days, respectively. Nymphs and adults of this phytoseiid can consume an average of 10.6 eggs per day and a total of 493 eggs during their active life cycle. In India Gupta (2001) cites *Amblyseius*

longispinus (= Neoseiulus longispinus Evans 1952) (Acari: Phytoseiidae) and *Stethorus parcempunctatus* and Jauravia sp. (Coleoptera: Coccinellidae) as important natural enemies in the area of Karnanka, while in the area of Kerala the prevalent predators are *A. channabasavannai* and *Stethorus tetranychi* Kapur. In India, *Amblyseius raoiellis* also is known to prey on *R. indica.* Nothing is known about the biology of this species. A related mite, *Amblyseius near raoiellis* has been collected in lime and mango in south Florida in fruits infested with *Brevipalpus phoenicis* (Peña, unpubl*ished data*). Ochoa (pers. comm) collected the predaceous mite *Neoseiulus longispinosus* (Evans), an old world species, preying on *R. indica* in Saint Lucia. Other natural enemies reported preying on *R. indica* in the Caribbean are *Amblyseius largoensis* (Phytoseiidae), *Armascirus taurus* (Kraemer) (Cunaxidae) and *Telsimia ephippiger* Chapin (Coccinellidae: Coleoptera).

Pathogens

A small portion of *R. indica* mites were observed by Ochoa (pers. Comm.) to be infected by a fungus, possibly, *Hirsutella* spp. Rosas-Acevedo and Sampedro-Rosas (2006) observed that the tenuipalpid *Brevipalpus phoenicis*, was infected by some isolates of *Hirsutella thompsoni.* However, only the H_tM130 strain of *H. thompsoni* var. *thompsoni* displayed exudate formation of the sporulative phase. The same authors emphasize the importance of assessing the presence of native entomopathogens, before introducing commercial microorganisms or isolations from elsewhere so as not to affect the natural regulatory systems.

Detection

Federal and state plant pest regulations are designed to minimize the risk of introduction of exotic pests into Florida and elsewhere in the US. Enforcement of these regulations undoubtedly is largely effective, but unfortunately the high volume of travel and commerce in the world today has resulted in an unprecedented number of new exotic pest introductions into Florida and many other localities in recent years. New pests that are detected early before they spread over a large area may sometimes be eradicated. Therefore, professionals concerned with plant health in southern Florida and the Caribbean Region should be vigilant for the possible arrival of the red palm mite in countries not already affected.

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Table 1. Host plant species of *Raoiella indica*.

Plant Species	Family	Distribution
Aiphanes sp.	Arecaceae	St. Lucia
Areca catechu L.	Arecaceae	Asia
Areca sp.	Arecaceae	Asia
Cocos nucifera L.	Arecaceae	Asia, Mauritius, St. Lucia, Martinique, Dominica, Trinidad, Guadeloupe, St. Martin
Dictyosperma album (Borg.)	Arecaceae	Asia
Dypsis lutescens (H. Wendl.)	Arecaceae	Asia
Phoenix dactilifera	Arecaceae	Asia, Mauritius, Israel, Egypt
Syagrus ramanzoffianum Glassman	Arecaceae	St. Lucia
Veitchia merrillii (Becc.)	Arecaceae	St. Lucia, Martinique
Licuala grandis H. Wendl.	Arecaceae	Guadeloupe
Caryota mitis Lour.	Arecaceae	Guadeloupe
Pricthardia pacifica B. C. Seem	Arecaceae	Guadeloupe
Washingtonia robusta H. E. Moore	Arecaceae	Guadeloupe
Musa spp.	Musaceae	Trinidad
Musa acuminata Colla	Musaceae	St. Lucia, Dominica
M. balbisiana Colla	Musaceae	St. Lucia, Dominica
Musa uranoscopus Lour.	Musaceae	St. Lucia
Musa x paradisiacal L.	Musaceae	St. Lucia, Dominica

Table 1. Host plant species of *Raoiella indica*.

Plant Species	Family	Distribution
Ocimum basilicum L.	Lamiaceae	Asia
Undetermined ginger	Zingiberaceae	St. Lucia
Undetermined heliconia	Musaceae	Trinidad
Heliconia rostrata R.	Heliconaceae	Guadeloupe
Strelitzia reginae Banks	Stretlitziaceae	Guadeloupe
Alpinia purpurata Vieill. ex. Schum.	Zingiberaceae	Guadeloupe
Etlingera elatior (Jack.) R. M. Smith	Zingiberaceae	Guadeloupe