THE RED PALM MITE, *RAOIELLA INDICA*: EFFECT OF RESIDENT AND COMMERCIAL PRODUCED PREDATORS AGAINST A RECENTLY INTRODUCED PEST IN FLORIDA, USA

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ABSTRACT.

The red palm mite, *Raoiella indica* Hirst invaded the Caribbean in 2004 and Florida, USA during the last month of 2007. Previous to the arrival of *R. indica* in Florida, surveys were undertaken to determine the current beneficial fauna inhabiting plant hosts of *R. indica*. Predators present included, *Amblyseius largoensis* (Acari: Phytoseiidae), *Bdella distincta* (Acari: Bdellidae), *Stethorus utilis* (Coleoptera: Coccinellidae) and *Chrysoperla spp.* (Neuroptera: Chrysopidae) among others. After the arrival of *R. indica*, predaceous fauna have been dominated by *A. largoensis* representing 77.2% of the total predators collected, followed by *Aleurodothrips fasciapennis* (Franklin) (Thysanoptera: Phlaeothripidae) (20%), while other predators (i.e., *B. distincta*, *S. utilis* and *Chrysoperla spp.*), have been found less frequently. No significant correlations have been determined until now between the population levels of natural enemies and population levels of *R. indica* (*F₁, 3 = 2.36; P = 0.21; F₁,2 = 1.3; P = 0.49*) for Broward and Palm Beach, respectively. Preliminary tests of the efficacy of the predator, *Amblyseius swirski*, show some promise, but further tests are necessary to determine its role for the management of the red palm mite.

INTRODUCTION.

The red palm mite, *Raoiella indica* Hirst. (Acari: Tenuipalpidae), also known as the coconut mite (Somchoudhury & Sarkar 1987), coconut red mite (Jalaluddin & Mohanasundaran 1990), red date palm mite (Elwan 2000), leaflet false spider mite (FAO 2005), frond crimson mite, scarlet mite (Gassouma 2005) is an important pest of coconuts, date palm, other palm species (PROSEA 2006), and 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 & Fletchmann, 2006), and in Puerto Rico (Rodrigues et al. 2007). The red palm mite was discovered in Florida during December 2007 (Peña et al. 2008). Damages to coconut, ornamental palms and bananas are extensive. It is considered that the pest has serious consequences for the coconut, ornamental palm and banana industries of the Caribbean islands. Damage to coconuts results in a 70% yield reduction and possibly job losses leading to a major socio-economic problem for some of the islands (Mr. Philippe Agostini, President Trinidad and Tobago Coconut Growers Assoc., Pers. Comm). In Florida,
cost of regulatory actions, such as precautionary sprays before shipping *R. indica* hosts to other states, will represent an additional production cost of more than half a million dollars to palm nursery producers per year.

*Raoiella indica* is found on the underside of the leaves of the host plant in very large numbers. Attacked leaves display severe yellowing followed by necrosis. Heavy mite infestations result in death of young plants. Management programs for this mite in areas where it is present as well as preventative programs for areas where it has not yet arrived are urgently needed. Past chemical control tactics against *R. indica* were proven inefficacious and costly in India and Egypt, but they are considered necessary for regulatory purposes in infested palm exporting areas (Florida & Puerto Rico).

Biological control is one of the most important alternatives to conventional pesticide use in pest management. Biological control is free of many problems associated with pesticide use, such as pest resistance, environmental pollution, and worker health impacts. Classical biological control, or the introduction of natural enemies from the areas of origin for *R. indica* has been initiated under the auspices of APHIS, PPQ (Marjorie Hoy, Pers. Comm.), resulting in the quarantine screening of one classical biocontrol candidate. Prior to release of any exotic predator, it is necessary to put greater emphasis on other areas of biological control, such as natural enemy conservation and augmentation.

In India, during a survey for indigenous predators, several predators were discovered preying on *R. indica*. The phytoseiid mite, Amblyseius channabasavanni and a beetle, Stethorus keralicus Kapur (Coleoptera: Coccinellidae) were considered to be the most important predatory species (Daniel 1981). Puttaswamy & Rangaswamy (1976) cite S. keralicus 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 red palm 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). He determined that *A. channabasavanni* females consumed eggs and female host mites. 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 maximal during May to June when the prey was at its peak.

Moutia (1958) observed that in Mauritius the principal predator of *R. indica* in coconut plantations was Typhlodromus caudatus Chant (Amblyseius caudatus Berlese). Gupta (2001) cites Amblyseius longispinus (= Neoseiulus longispinus Evans 1952) (Acari: Phytoseiidae) and Stethorus parcempunctatus and Jauravia sp. (Coleoptera: Coccinellidae) in the area of Kannaka while in the area of Kerala, the prevalent predators are *A. channabasavannai* and *Stethorus tetranychii*.

The objectives of this study were 1) to determine the density of predators and herbivorous micro-arthropods associated with palms and bananas in Florida before the arrival of *R. indica* and record the response of the current beneficial fauna to the invading mite and to 2) initiate preliminary tests to determine which commercially available predators will reproduce, feed and survive on a *R. indica* diet.
MATERIALS AND METHODS.

Generalist fauna prior to invasion by the red palm mite.

A survey for natural predators infesting palms and bananas was conducted in South Florida where most of the palm, *Musa*, gingers and heliconid production is concentrated. Monthly surveys were conducted in Miami-Dade and Monroe counties on coconut palms and on bananas. Twenty pinnae per frond were collected per palm species while 20 sections (ea. ~ 60 cm²) were removed from a banana leaf. Samples were taken to the laboratory, where microarthropods, i.e., tetranychids, tenuipalpids, diaspids, phytoseiids, bdellids and others were recorded, labeled and mounted and sent for identification by specialists, and densities of these spp. determined.

Naturally occurring generalist predators currently preying on *R. indica* in Florida.

Eight coconut palms were selected in two areas, West Palm Beach (26°42'54"N 80°02'22"W) and Broward (26°07'28"N 80°14'58"W). Once each month, since the time of the discovery of the *R. indica* invasion on December 2007, 1 pinna was collected from each of two fronds per palm totaling 16 samples per site. Each pinna was placed in a plastic bag, sealed and placed in a refrigerated cooler, and frozen before evaluation. Each sample was evaluated under the microscope, and number of red palm mite, tetranychids, diaspidid scales, whiteflies, mealybugs and different predaceous arthropods (Phytoseiidae, Neuroptera, Thripidae, Coccinellidae) recorded.

Potential efficacy of commercial predators for control of *R. indica*.

Several commercially produced predators will be tested for efficacy to feed, survive and reproduce on *R. indica* (i.e., Amblyseius swirski, Phytoseiulus persimilis, Neoseiulus longipes, N. californicus, Galendromus occidentalis). The predator, Amblyseius swirski was selected for a preliminary trial under laboratory conditions. The arena consisted of a 5 cm petri dish placed inside of a 12 cm Petri dish. Water was added to the larger Petri dish to prevent predator or prey escape from the arena. A 4 cm² section of a coconut frond that held a known number of different stages of *R. indica* was added. Then, a presumably-mated 1 to 2 day old single female was individually placed inside of each arena. The numbers of eggs, nymphs and adults consumed daily were calculated and new food sources added daily.

Preliminary field trials with a commercial predator.

Five coconut palms infested with *R. indica* were selected. Ten pinnae from different fronds were collected per palm and the number of *R. indica* and predatory phytoseiids recorded from a 100 cm² section of a each pinna. Then, a Swirski-mite plus® sachet containing approximately 250 predators was hung from the middle canopy of each palm. *R. indica* and phytoseiid densities were assessed 1 month after.
RESULTS AND DISCUSSION

Generalist fauna prior to invasion by the red palm mite.

The scale, *Aonidiella orientalis* (Newstead) (Heteroptera: Diaspididae), the whitefly, *Aleurocanthus woglumi* Ashby (Heteroptera: Aleyrodidae), and the spider mites, *Tetranychus* spp., and *Tetranychus gloveri* Banks (Acari: Tetranychidae), were the most common microarthropods inhabiting coconuts, while *Tetranychus* sp., and *Brevipalpus* spp., were the most common inhabiting bananas from 2006 to 2008 in areas before the arrival of *R. indica* (Figs 1 and 2). On coconuts, *Amblyseius largoensis* (Muma) (Acari: Phytoseiidae), *Stethorus utilis* (Horn) and *Chrysoperla* spp., (Neuroptera: Chrysopidae) were the most common predators followed by *Bdella distincta* (Barker and Bullock) (Acari: Bdellidae) and *Aleurodothrips fasciapennis* (Franklin) (Thysanoptera: Phlaeothripidae). On bananas, the predators *Amblyseius* spp., and *Stethorus utilis* were recorded (Figs 3 and 4). *Amblyseius largoensis* was the only phytoseiid on coconuts, while the species identification of the *Amblyseius* found in bananas is pending. *Amblyseius largoensis* is a generalist feeding not only on mites, but also on pollen (Yue & Tsai 1996). A study conducted in Brazil to determine survival of *A. largoensis* on *Aceria guerreronis* (Acari: Eryophidae), a pest of coconuts, determined that a mix diet of *A. guerreronis*, or *T. urticae* + pollen and + honey increased its fertility parameters (Galvao et al., 2008). *Amblyseius largoensis* was one of two predators found in Philippines in association with *R. indica* (Gallego et al., 2002), but its efficacy has not been determined. *Amblyseius largoensis* has been also found in association with *A. guerreronis* on coconuts fruits affected with the eriophyiid, but no clear prey preference has been determined for this predator on this plant (Reis et al. 2008). The predaceous thrips, *A. fasciapennis* has been previously reported feeding on eggs of diaspidid scales such as *Chrysomphalum aonidum* and *Aspidiotus nerii* and on eggs of the pyralid moth, *Corcyra cephalonica* (Watson et al., 2004; Beshear & Nakahara 1975). *Stethorus utilis* is cited as a common predator of tetranychid mites (Chazeau 1985). In general, because of the high densities of both diaspidids and aleyrodids present on coconuts, the prey preference for the native predators needs further study under Florida conditions.

Naturally-occurring generalist predators currently preying on *R. indica* in Florida.

In the area of Palm Beach, where early colonization of *R. indica* is suspected, a total of 217,622 mites were collected per pinna between January and June, 2008; average *R. indica* densities fluctuated between 1000 to 1200 per pinnae during the winter months (January –February) and peaked during March (approx. 4,000), with a slight reduction during the following months (April to June) (Fig 5). A total of 166 *A. largoensis* were collected between January-June 2008. *A. largoensis* represented 77.2% of the total predators collected, followed by *A. fasciapennis* (20%), while other predators (i.e., *B. distincta, S. utilis* and *Crysoperla* spp.), were only a small proportion of the total (2.8%).
The relation between phytoseiid predators, i.e., *A. largoensis* and the potential new prey was erratic. For instance, while an increase on predator density was observed following an increase on the prey during January-February, and May-June, 2008, numbers of predators were still consistently low, compared to the number of prey present. In the area of Broward, a total of 45,280 red palm mites were collected per pinna between January and June, 2008; This is a much lower density than that of Palm Beach. Average *R. indica* densities fluctuated ca. 100 to 1,600 mites per pinnae (Fig 6). A total of 22 *A. largoensis* was collected between January to June, 2008 in that area. An increase of predator density was not observed until the month of June, approx. 6 months after the detection of the pest.
Fig 5. Raoiella indica population and phytoseiid densities after the invasion of the red palm mite in West Palm Beach, FL, USA

Fig 6. Raoiella indica population and Phytoseiid densities after the invasion of the red palm mite in Broward, FL, USA

No significant correlations were found between the population levels of natural enemies and population levels of R. indica (F1,3 = 2.36; P = 0.21; F1,2 = 1.3; P = 0.49) for Broward and Palm Beach, respectively. While we have not reached one year from the discovery of the infestation of R. indica in Florida, at this point, it is doubtful that the predator, A. largoensis will be capable of maintaining the prey under lower densities than those observed until now (Figs 5 and 6). No significant correlations between abiotic factors (temperature, precipitation) and the population levels of R. indica were observed during these months at either site (Temperature: F 1,3 = 5.83; P = 0.09 for Broward and F1,3 = 1.70; P = 0.28 for Palm Beach. Precipitation: F1,3 = 0.08; P = 0.79 for Broward and F1,3 = 1.75; P = 0.27 for Palm Beach).

Potential efficacy of commercial predators for control of R. indica.

A female of A. swirsiki consumed a daily average of 7.06 ± 0.61 eggs, 2.49 ± 0.21 larvae, 3.25 ± 0.29 nymphs and 8.90 ± 0.55 adults of R. indica. Female longevity was 11.54 ± 0.72 days with an average daily oviposition of 1.1 ± 0.10 eggs per day. It is not known what would be the predation potential of immatures of this species on R. indica.

Preliminary field trials with a commercial predator.

A significant reduction on R. indica was observed 1 month after release of 250 A. swirsiki per palm in the area of Manalapan (F1,18 = 13.66, P = 0.001). However, no significant increases on phytoseiid densities were recorded (Fig 7). Further studies are needed to determine the effectiveness under field conditions of A. swirsiki as a predator of R. indica.
The beneficial fauna inhabiting coconut palms in Florida is diverse and it their numbers have increased after the arrival of the red palm mite, *Raoiella indica*. This increase, although significant has not substantially reduced the density levels of the red palm mite. Other tactics, either focusing on augmentation or on introduction of other predators should be the next step to promote effective biological control of the mite.

REFERENCES


