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SEARCH FOR NATURAL ENEMIES OF *RAOIELLA INDICA* HIRST IN RÉUNION ISLAND (INDIAN OCEAN)

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ABSTRACT — Since it first appeared in the New World in 2004, the palm red mite, *Raoiella indica* Hirst, has spread to many countries, from Florida (USA) to the northern part of Brazil. In this region, this mite has been recorded on several different hosts, but it has been most harmful to coconut. For different reasons, the chemical control of this pest is not feasible, and biological control has been considered an important measure to be pursued. The objective of this paper is to provide details about an effort to determine potential natural enemies of *R. indica* from La Réunion, for their possible introduction in northern Brazil. The only natural enemy consistently found in association with *R. indica* was identified as the phytoseiid *Amblyseius largoensis* Muma. A colony of this species was established with specimens collected from different parts of the island. This colony was introduced to Brazil, where subsequent assessments should indicate whether or not it should be released in the field.

KEYWORDS — Acari; predator; biological control; palm tree

INTRODUCTION

The palm red mite, *Raoiella indica* Hirst, was originally described about 88 years ago (Hirst, 1924) from Coimbatore, State of Tamil Nadu, in southern India. It was then reported from the following other countries in the Old World: Egypt (Sayed, 1942), Mauritius (Moutia, 1958), Sudan (Pritchard and Baker, 1958), Pakistan (Chaudhri, 1974), Israel (Gerson *et al*., 1983), La Réunion (Quilici *et al*., 1997), Oman (Elwan, 2000) and Iran (Arbabi *et al*., 2002). There is some confusion in the literature in relation to the plants attacked by *R. indica*, given that some authors cited this species on some dicotyledonous plants, while all the evidence suggest that it feeds and reproduces only on monocots (Carrillo *et al*. 2011). It seems that before its introduction to the New World, it was only positively known

from three host species, all belonging to the family Arecaceae, namely coconut (*Cocos nucifera* L.), date (*Phoenix dactylifera* L.) and areca nut palm (*Areca catechu* L.).

Raoiella indica was first found in the New World in 2004, where it was discovered on *C. nucifera* on the island of Martinique (Flechtmann and Etienne 2004). Since then, it has been reported from most of the Caribbean islands, Florida (USA), southern Mexico, northern Venezuela, northern Colombia and northern Brazil (Kane *et al*. 2005; Flechtmann and Etienne 2006; Rodrigues *et al*. 2007; FDACS 2007; NAPPO 2009; Carrillo *et al*. 2011a; Navia *et al.* 2011). In this part of the world, *R. indica* has been found on a much larger number of hosts, including species of Arecaceae, the main group of hosts, as well as species of several other families.

Published information on the damage caused by *R. indica* is very scanty, but it has been mentioned in the older literature as a pest of dates and coconuts in Asia (Jeppson *et al*. 1975). In the New World, it has been cited mainly as a pest of coconut, not only due to its effect on the yield of coconut, but also on its deleterious effect on the esthetic quality of the trees, which are used as ornamental plants in many tropical and sub-tropical countries. *Raoiella indica* has caused a particular type of damage in Brazil. Although it has not affected the yield of coconut or other hosts, it has caused considerable losses to banana growers of the region where the pest has been found, because of the trading restrictions imposed on them as a measure to reduce the chances of dispersing the pest to other parts of the country.

Chemical control would seem a logical means to reduce damage caused by *R. indica*. However, there are several constraints to the widespread use of this measure. First of all, in most countries there are no chemicals registered for the control of this pest. Secondly, coconut plants grown in most countries are too tall to allow miticides to be easily applied. Thirdly, coconut, the main host, is produced mainly by small growers, many of whom have no experience with the use of these products, running the risk of intoxicating themselves or causing environmental hazards; in addition, small growers would not afford the increasing cost to apply miticides regularly to control the pest.

Thus, it seems that biological control could constitute an ideal control measure to be implemented. In a recent publication, Carrillo *et al*. (2011b) summarized the published information about the association of this pest with natural enemies. However, much remains to be done, given that most of the corresponding papers do not provide details about the actual potential of those natural enemies as control agents. Thus, the biological control of *R. indica* could entail an extensive research project.

Usually, a project of classical biological control starts with the definition of priority areas for the search of potential natural enemies to be used in a particular newly invaded area and ends with the actual field colonization of the introduced natural enemies. The objective of this paper is to provide details about an effort to determine potential natural enemies of *R. indica* for introduction in northern Brazil.

MATERIALS AND METHODS

The first step of this work consisted of determining priority areas to search for potential natural enemies. We took into consideration published and unpublished information about the distribution of the pest and the level of damage it has been reported to cause in each region. A considerable part of the information about the natural enemies associated with *R. indica* came from India. However, we did not consider India to be a priority area to search for the natural enemies, given the available reports indicating that it causes damage to coconut in that country (Sarkar and Somchoudhry 1988). Conversely, in the experience of one of the authors of this paper (S. Kreiter), *R. indica* is found on coconut in La Réunion, but at levels that were not considered sufficient to cause major damage. Thus, it was decided that a search should be conducted on this island.

An exploration was conducted on the island in February 2011. Most of the lowland areas of the island were visited in search of coconut plants which were then examined for the presence of *R. indica*. Coconut is not an important crop in La Réunion,

and few commercial fields are found in Saint-Louis, in the southwestern part of the island. Except for plants of this plantation, all other plants examined were isolated or grown in small groups, mostly as ornamentals. Given the relatively low number of these plants on the island, samples of other palm plants were also collected.

Samples of different plant parts were placed in paper bags inside plastic bags and stored in a cool box for transport to the laboratory. In the laboratory, the samples were examined under dissecting microscopes. When mites that seemed to be *R. indica* were found in relatively high numbers, a few representative specimens were collected for species confirmation; all other mites found were collected and immediately mounted in Hoyer´s medium for later identification, except for the mites of the Phytoseiidae family. The latter were collected and isolated in rearing units in an attempt to initiate colonies. Each unit consisted of a small piece of coconut leaflet which was placed with the upper side of the leaf facing downward onto a piece of wet foam mat, where they were fed a mixture of different stages of *R. indica* and pollen of *Ricinus communis* L. After a few eggs were laid, the adult females were mounted in Hoyer´s medium for identification.

At the end of the trip, an agreement was signed between CIRAD and Universidade Federal Rural de Pernambuco, Brazil, to allow the shipment of the selected species to Brazil. At the same time, a permit was obtained from the Brazilian Ministry of Agriculture (Permit number 21016.000668/2010-38) for the introduction of the imported specimens for experimental purposes. The specimens to be shipped were sucked in pipette tips; to allow air circulation and to provide a source of water, the wider end of the tip was covered with a fine cloth and the narrower end was covered with a piece of damp cotton wool fixed in place with parafilm. The introduced mites were quarantined at Laboratório de Quarentena "Costa Lima", Embrapa Meio Ambiente, Jaguariúna, State of São Paulo, Brazil. While in quarantine, they were fed solely with pollen of the lesser bulrush (or narrow leaf cattail or lesser reedmace), *Typha angustifolia* L. (Typhaceae).

Results and discussion

A variety of mite species was found on coconut and other palm plants in La Réunion (Table 1). In total, 4,799 specimens of 22 species belonging to 11 different mite families were found. Three of these families are constituted exclusively by phytophagous mites, five to families of predatory mites and three to families of variable feeding habits.

Raoiella indica was frequently found on the coconut plants that were examined, though usually in relatively low numbers, although high infestations were observed in Saint-Benoit and Saint-Louis. However, its predominance among the mites that were found on the plants may be due to the fact that sampling was directed towards plants that showed symptoms of attack by *R. indica*, given our interest on collecting predators associated with this species. Damage caused by this mite was commonly confused with that caused by a scale, *Aspidiotus destructor* Signoret (Hemiptera: Diaspididae), with which it was usually associated. Plants that were highly infested by both species had yellow leaves. In addition to coconut, *R. indica* was also found on *Acanthophoenix rubra* (Bory) H. Wendl. and on an unidentified plant of the same genus, which represent new hosts of this mite for the Old World. The incidence of *R. indica* was much higher on the latter species. *Acanthophoenix rubra* was reported by Carrillo *et al*. (2011) as a new host of *R. indica* in Florida, USA. The second most common phytophagous mite on coconut leaves was an undescribed species of *Notostrix* (Eriophyidae). Several papers have been published about the plant mites from La Réunion Island (Gutierrez 1968; Gutierrez and Etienne 1986; Ueckermann and Loots 1985; Quilici *et al*. 1997, 2000; Kreiter *et al*. 2002), but apparently nothing about the mites inhabiting coconut palms.

The only predator species consistently found in association with *R. indica* was identified as the phytoseiid *Amblyseius largoensis* Muma, which was found together with *R. indica* in 10 of the 20 leaf samples in which the latter was found. Considering their total numbers, an average of one *A. largoensis* was found for about every eight *R. indica*. Given the known generalist behavior of this predator (Mc-

TABLE 1: Mite species collected on La Réunion Island in February 2011 when searching for potential natural enemies of *Raoiella indica* on different palm trees (Arecaceae).

	Mites	Plants		Localities	Numbers	
Family	Species	Species	Part[1]		Specimens	Samples[2]
Plant feeding						
Eriophyidae	*Aceria guerreronis* Keifer	*Cocos nucifera*	F	Étang Salé, Hern Hermitage-les-Bains, St. Paul, St.-Pierre, Sainte-Suzanne	1328	11
	Notostrix n. sp.	*C. nucifera*	L	Étang Salé, Saint-Benoit, St. Louis, St. Paul, St. Suzanne	234	8
Tarsonemidae	*Nasutitarsonemus omani* Lofego & Moraes	*C. nucifera*	F	Sainte-Suzanne	5	1
Tenuipalpidae	*Brevipalpus hondurani* Evans	*Chamaedorea seifrizii*	L	Le Tampon	1	1
	Phyllotetranychus romaine Pritchard & Baker	Arecaceae (not identified)	L	Grande Anse	4	1
	Raoiella indica Hirst	*Acanthophoenix rubra* *Acanthophoenix* sp., *C. nucifera*	L	Étang Salé, Grande Anse, Le Maïdo, St. Benoit, St.-Leu, Saint-Paul, Saint-Pierre, St. Suzanne	2728	20
	Tenuipalpus n. sp.	*Acanthophoenix rousselii*	L	Le Tampon	1	1
Tetranychidae	*Oligonychus plegas* Baker & Pritchard	*C. nucifera*	L	Étang Salé, Grande Anse, St. Benoit, St. Leu, St.-Paul	83	11
	Oligonychus sp.	*C. nucifera*	L.	Grande Anse, Saint-Benoit, St. Leu, St. Pierre		
	Eotetranychus sp.	*Euterpe edulis*	L	Le Tampon	10	1
Mainly Predators						
Bdellidae	*Bdellodes* sp.A	*C. nucifera*	L	Étang Salé, Saint-Paul, St. Pierre	6	5
	Bdellodes sp.B	*C. nucifera*	L	Étang Salé, Saint-Paul	3	2
	Bdellodes sp.C	*C. nucifera*	L	Saint-Paul	2	1
Cheyletidae	*Paracheyletia* sp.	*C. nucifera*	L	Grande Anse, St.-Benoit, St. Leu, St. Louis	9	4
Cunaxidae	*Armascirus* sp.	*C . nucifera*	L	St.-Paul	1	1
Eupalopsellidae	*Peltasellus* sp.	*C. nucifera*	L	Grande Anse	1	1
Phytoseiidae	*Amblyseius largoensis* Muma	*C. nucifera* , Arecaceae (not identified)	L	Étang Salé, Grande Anse, Le Maïdo, St. Benoit, St. Leu, Saint-Paul, Saint-Pierre, St. Suzanne	358	19
	Neoseiulus recifensis Gondim Jr. & Moraes	*C. nucifera*	L	Saint–Leu	7	2
	Typhlodromus (*Anthoseius*) *moraesi* Kreiter & Ueckermann	*C. nucifera*	L	Saint-Pierre	7	1
Variable feeding habit						
Acaridae	*Tyrophagus* sp. A	*C. nucifera*	F	Saint-Paul, Sainte-Suzanne	9	3
	Tyrophagus sp. B	*C. nucifera*	F	Étang Salé, Saint-Paul	9	3
Ameroseiidae	*Neocypholaelaps* n. sp.	*C. nucifera*	I	Saint-Pierre	50	2
Tydeidae	*Metapronematus* sp.	*C . seifrizii*	L	Le Tampon	4	1

[1]L: leaves; F: fruits; I: inflorescences ; [2]Total number of samples: Fruits, 15; Leaflet: 54; Inflorescences: 3

Murtry and Croft 1997; Galvão *et al*. 2007), in nine samples it was associated either with other mites or with no mites (perhaps feeding on pollen). Other predatory mites of the same family (two species) or of five other families (seven species) were found quite sporadically.

Thus, only this predator was colonized in the laboratory. Given the low number of predators collected in the different sites visited on the island and the relatively homogeneous habitat in which they were found, a single colony was maintained, with a mixture of specimens from the different parts of the island. At the end of the exploration period, a total of 190 specimens and 30 eggs were available for shipment.

The mites were received in quarantine on February 28, 2011. They were released from quarantine on March 18, 2011 for detailed laboratory evaluations and eventual field releases.

The predator species selected for shipment (*A. largoensis*) had already been reported from La Réunion on coconut plant (Quilici *et al*., 1997). This cosmopolitan species has been reported from many tropical and subtropical countries around the world (Moraes *et al*. 2004). It has been reported from coconut palms in several countries, including Brazil (Carrillo *et al*. 2011b). It might also correspond to the species reported from Mauritius, an island relatively close to La Réunion, as *Amblyseius caudatus* Berlese (Moutia 1958; Carrillo *et al*. 2011b).

Given the fact that *A. largoensis* is already known from Brazil, it was initially questioned whether it would be worthwhile to proceed with the shipment. However, it was decided for the introduction to be done, to allow a comparison between the Brazilian population and the population collected in La Réunion, letting the decision about the possible field release to be taken on the basis of that comparison. It is not known for how long *R. indica* and *A. largoensis* have been present in La Réunion, nor how their association evolved. It seems conceivable that the La Réunion population of *A. largoensis* is a key factor in maintaining *R. indica* population under lower levels than observed in many countries in the New World, where it has been only recently found.

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