Crop Protection Compendium

Datasheet report for Raoiella indica (red palm mite)

Pictures

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Picture	Title	Caption	Copyright
	Adult mite	The red palm mite (Raoiella indica), an invasive species in the Caribbean, may threaten several important palms found in the southern USA. (Original magnified approx. 300x.) Photo by Eric Erbe; Digital colourization by Chris Pooley.	USDA-ARS
	Colony of mites	Colony of red palm mites (Raoiella indica) on coconut leaflet, from India.	Bryony Taylor
	Colony of mites	Close-up of a colony of red palm mites (Raoiella indica) on coconut leaflet, from India.	Bryony Taylor

Identity

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Preferred Scientific Name

Raoiella indica Hirst (1924)

Preferred Common Name

red palm mite

International Common Names

English: coconut red mite; frond crimson mite; leaflet false spider mite; red date palm mite; scarlet mite

EPPO code

RAOIIN (Raoiella indica)

Taxonomic Tree

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Domain: Eukaryota
Kingdom: Metazoa
Phylum: Arthropoda
Subphylum: Chelicerata
Class: Arachnida
Subclass: Acari
Superorder: Acariformes
Suborder: Prostigmata
Family: Tenuipalpidae
Genus: Raoiella
Species: Raoiella indica

Notes on Taxonomy and Nomenclature

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R. indica was first described in the district of Coimbatore (India) by Hirst in 1924 on coconut leaflets [*Cocos nucifera*]. A comprehensive taxonomic review of the genus and species was carried out by Mesa et al. (2009), which lists all suspected junior synonyms of *R. indica,* including *Raoiella camur* (Chaudhri and Akbar)*, Raoiella empedos* (Chaudhri and Akbar)*, Raoiella obelias* (Hasan and Akbar)*, Raoiella pandanae* (Mohanasundaram), *Raoiella phoenica* (Meyer) and *Raoiella rahii* (Akbar and Chaudhri). The review also highlighted synonymy with *Rarosiella cocosae* found on coconut in the Philippines. The review by Mesa et al. (2009) also lists the redescriptions by several authors.

Description

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R. indica is a small red mite, which is characterized by the presence of long spatulate setae on its dorsum, often with a drop of liquid on the end. The body shape is oval and flattened and the male can be distinguished from the female by the distinct triangular abdomen (Kane and Ochoa, 2006; Welbourn, 2006). All stages of the mite are red; however, the adult females often have darkened areas on their abdomen. There are five distinct life stages: egg, larva, protonymph, deutonymph and adult. The original description by Hirst (1924) stated that the length of the adult female (including palpi) is 0.29-0.30 mm and the male is 0.21 mm. Redescriptions have quoted the length of the adult female as between 267-300 µm and the width between 178 and 215 µm (Hirst, 1924; Taher Sayed, 1942; Sadana, 1997). The eggs are approximately 0.117 mm long, red/orange and smooth and shiny in appearance (Moutia, 1958) and are found attached to the leaf by a stipe that is roughly twice as long as the egg (Kane and Ochoa, 2006). Zaher et al. (1969) stated that the length of the larva was 125 µm long and 93 µm wide, the protonymph 210 µm long and 159 µm wide, and the deutonymph 272 µm long and 179 µm wide. Welbourn (2006) stated that the dorsal and lateral setae of nymphs are distinctly shorter than those of the adult, and dorsal setae are not set in tubercules (projecting setal bases).

Summary of Invasiveness

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R. indica was first described in India in 1924 (Hirst) and has since been reported in several Old World countries. The species became of recent significance in 2004 when it was first reported in the Caribbean (Flechtmann and Étienne, 2004). Since then the mite has successfully spread throughout the islands of the Caribbean and has expanded its range into southern Florida (USDA-APHIS, 2007), South America (northern Venezuela, Vásquez et al., 2008; Brazil, Navia et al., 2010; Colombia, Carrillo et al., 2011) and Mexico (Estrada-Venegas et al., 2010). The mite has been reported on a wide range of palm hosts of the family Arecaceae and apparent new associations with members of the order Zingiberales, including the families Musaceae, Heliconiaceae, Zingiberaceae and Strelitziaceae have been reported. The success of the mite in the invasive range may be attributed to its ability to colonize many different host plant species, its apparent lack of co-evolved natural enemies in its new habitat and its rapid dispersal in its new range.

Distribution

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The majority of literature on *R. indica*, previous to its introduction into the Caribbean, was published in India, where the mite was first described (Hirst, 1924). *R. indica* is a well-established pest throughout palm growing areas of India and reported mainly on *Cocos nucifera* (Hirst, 1924) and *Areca catechu* (Daniel, 1979; Yadavbabu and Manjunatha 2007). Outside India, older literature reported *R. indica* in Egypt, UAR, (Taher Sayed, 1942; Zaher et al., 1969), Sudan (Couland, 1938, cited in Pritchard and Baker, 1958) Mauritius (Moutia, 1958) and Saudi Arabia (Soliman and Al-Yousif, 1979). More recently, further countries throughout Asia have been reported (see Distribution table). However, it is unknown how long the mite has been present in these countries. Dowling et al. (2010) have carried out a detailed molecular analysis with the aim to track the phylogenetic history of *R. indica*. They found the most primitive haplotypes of *R. indica* were found in the Middle East and these appear to have spread throughout the Old World and eventually to the Caribbean, indicating that perhaps the mite has been present in the Asian region for some time. *R. indica* was first reported in the New World in Martinique (Flechtmann and Étienne, 2004) and has since spread rapidly throughout the Caribbean archipelago into Southern Florida (Smith and Dixon, 2008) and South America (Vásquez et al., 2008) and has now spread further into Mexico (Estrada-Venegas et al., 2010), Brazil (Navia et al., 2010) and Colombia (Carrillo, 2011). It has become of interest as an invasive in these countries due to the high population numbers and diverse range of host plants the mite has been recorded on.

Distribution Table

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The distribution in this summary table is based on all the information available. When several references are cited, they may give conflicting information on the status. Further details may be available for individual references in the Distribution Table Details section which can be selected by going to Generate Report.

Continent/Country/Region	Distribution	Last Reported	Origin	First Reported	Invasive	Reference	Notes
Asia							
Cambodia (/cpc/datasheet/108472)	Absent, unreliable record					EPPO, 2014	
India (/cpc/datasheet/108459)	Present					CABI/EPPO, 2007; EPPO, 2014	
-Goa (/cpc/datasheet/108731)	Present					Raju, 1983; CABI/EPPO, 2007; EPPO, 2014	
-Karnataka (/cpc/datasheet/108738)	Widespread					Puttaswamy and Rangaswamy, 1976; Daniel, 1979; CABI/EPPO, 2007; EPPO, 2014	
-Kerala (/cpc/datasheet/108737)	Widespread					Kapur, 1961; Saradamma, 1973; Sathiamma, 1996; CABI/EPPO, 2007; EPPO, 2014	
-Madhya Pradesh (/cpc/datasheet/108743)	Present					Gupta and Gupta, 1979; CABI/EPPO, 2007; EPPO, 2014	
-Tamil Nadu (/cpc/datasheet/108751)	Widespread		Introduced	1924		Hirst, 1924; Loganathan et al., 2000; CABI/EPPO, 2007; EPPO, 2014	

Continent/Country/Region	Distribution	Last Reported	Origin	First Reported	Invasive	Reference	Notes
-West Bengal (/cpc/datasheet/108755)	Widespread					Sarkar and Somchoudhury, 1989a; Sarkar and Somchoudhury, 1989b; Sarkar and Somchoudhury, 1988; Senapati and Biswas, 1990; CABI/EPPO, 2007; EPPO, 2014	
Iran (/cpc/datasheet/108462)	Present					Arbabi et al., 2002; CABI/EPPO, 2007; EPPO, 2014	Sistan-Baluchestan and Hormozgan Provinces
Israel (/cpc/datasheet/108457)	Absent, formerly present					Kane et al., 2005; CABI/EPPO, 2007; EPPO, 2014	
Oman (/cpc/datasheet/108529)	Present					Elwan, 2000; CABI/EPPO, 2007; EPPO, 2014	Al-Dakhliya region
Pakistan (/cpc/datasheet/108537)	Present					Mansoor-ul-Hassan, and Shamshad, 2000; CABI/EPPO, 2007; EPPO, 2014	Punjab
Philippines (/cpc/datasheet/108535)	Present					Kane et al., 2005; CABI/EPPO, 2007; EPPO, 2014	Synonym Rarosiella cocosae reported
Saudi Arabia (/cpc/datasheet/108552)	Present					Soliman and Al-Yousif, 1979; CABI/EPPO, 2007; EPPO, 2014	
Sri Lanka (/cpc/datasheet/108485)	Present		Introduced	1977		FAO, 1977; CABI/EPPO, 2007; EPPO, 2014	
Thailand (/cpc/datasheet/108580)	Present					Kane et al., 2005	Pattaya and Bangkok
United Arab Emirates (/cpc/datasheet/108350)	Present					Gassouma, 2004; CABI/EPPO, 2007; EPPO, 2014	
Africa							

Continent/Country/Region	Distribution	Last Reported	Origin	First Reported	Invasive	Reference	Notes
Benin (/cpc/datasheet/108375)	Present	2010				Zannou et al., 2010	Surveys found it between 2004 and 2010
Egypt (/cpc/datasheet/108418)	Present					Taher Sayed, 1942; Zaher et al., 1969; CABI/EPPO, 2007; EPPO, 2014	First reported in 1942. Found in lower and upper areas of Egypt, but rather confined to certain areas (Sayed,1942). Recorded on date palm, Phoenix dactylifera
Mauritius (/cpc/datasheet/108510)	Present					Moutia, 1958; CABI/EPPO, 2007; EPPO, 2014	
Namibia (/cpc/datasheet/108516)	Present					Giliomee and Ueckermann, 2016	
Réunion (/cpc/datasheet/108546)	Present					Ueckermann, 2004; CABI/EPPO, 2007; EPPO, 2014	
South Africa (/cpc/datasheet/108613)	Restricted distribution					IPPC, 2016	Detected in the Northern Cape Province near the town of Upington.
Sudan (/cpc/datasheet/108555)	Present					Baker and Pritchard, 1960; CABI/EPPO, 2007; EPPO, 2014	
Tanzania (/cpc/datasheet/108591)	Present	2010				Zannou et al., 2010	Reported in coconut orchards between 2004 and 2010
North America							
Mexico (/cpc/datasheet/108513)	Localised		Introduced	2009	Invasive	Estrada-Venegas et al., 2010; EPPO, 2014	Quintana Roo (state)
USA (/cpc/datasheet/108597)	Transient: actionable, under eradication					EPPO, 2014	
-Florida (/cpc/datasheet/108804)	Transient: actionable, under eradication		Introduced		Invasive	Smith and Dixon, 2008; EPPO, 2014	
Central America and Caribbean							

Continent/Country/Region	Distribution	Last Reported	Origin	First Reported	Invasive	Reference	Notes
Barbados (/cpc/datasheet/108368)	Restricted distribution					IPPC, 2010; EPPO, 2014	
Cuba (/cpc/datasheet/108405)	Present		Introduced	2007	Invasive	Rodríguez et al., 2007; EPPO, 2014	
Dominica (/cpc/datasheet/108413)	Present		Introduced	2005	Invasive	IPPC, 2005; Kane et al., 2005; CABI/EPPO, 2007; EPPO, 2014	
Dominican Republic (/cpc/datasheet/108414)	Present		Introduced	2007	Invasive	CABI/EPPO, 2007; EPPO, 2014	
Grenada (/cpc/datasheet/108432)	Present		Introduced	2007	Invasive	Welbourn, 2006; IPPC, 2007; EPPO, 2014	
Guadeloupe (/cpc/datasheet/108441)	Present		Introduced	2005	Invasive	Flechtmann and Étienne, 2004; CABI/EPPO, 2007; EPPO, 2014	
Guatemala (/cpc/datasheet/108445)	Present		Introduced	2018		Garcia Ochaeta, 2018	
Haiti (/cpc/datasheet/108453)	Present		Introduced	2007	Invasive	Welbourn, 2006; EPPO, 2014	
Jamaica (/cpc/datasheet/108465)	Present		Introduced	2007	Invasive	Welbourn, 2006; IPPC, 2007; EPPO, 2014	
Martinique (/cpc/datasheet/108506)	Present		Introduced	2004	Invasive	Flechtmann and Étienne, 2004; CABI/EPPO, 2007; EPPO, 2014	Reported on Veitchia merrillii and Cocos nucifera
Puerto Rico (/cpc/datasheet/108541)	Present		Introduced	2007	Invasive	CABI/EPPO, 2007; Rodrigues et al., 2007; EPPO, 2014	
Saint Lucia (/cpc/datasheet/108483)	Present		Introduced	2005	Invasive	Kane et al., 2005; CABI/EPPO, 2007; Jn Pierre, 2008; EPPO, 2014	
Saint Vincent and the Grenadines (/cpc/datasheet/108600)	Restricted distribution					IPPC, 2009; EPPO, 2014	
Trinidad and Tobago (/cpc/datasheet/108588)	Present		Introduced	2006	Invasive	Kane et al., 2005; CABI/EPPO, 2007; EPPO, 2014	
United States Virgin Islands (/cpc/datasheet/108603)	Present		Introduced	2007	Invasive	Welbourn, 2006; EPPO, 2014	

Continent/Country/Region	Distribution	Last Reported	Origin	First Reported	Invasive	Reference	Notes
South America							
Brazil (/cpc/datasheet/108381)	Present						Present based on regional distribution.
-Amazonas (/cpc/datasheet/108628)	Present					Rodrigues and Antony, 2011	
-Roraima (/cpc/datasheet/108647)	Localised		Introduced	2009	Invasive	Navia et al., 2010; Navia et al., 2011	Boa Vista and neighbouring municipalities
Colombia (/cpc/datasheet/108399)	Restricted distribution		Introduced		Invasive	Carrillo et al., 2011	
Venezuela (/cpc/datasheet/108601)	Present		Introduced	2007	Invasive	Vásquez et al., 2008; EPPO, 2014	High infestations found on banana and coconut leaflets in Sucre and Monagas
Europe							
Russian Federation (/cpc/datasheet/108550)	Absent, unreliable record					EPPO, 2014	

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History of Introduction and Spread

Although the exact area of origin is unknown for *R. indica,* the mite is well established in the reported areas in Asia and Africa. Current theories hypothesize that the mite has gradually spread west via natural dispersal and on infested material transported via trading routes. It is believed that the pest was first introduced into the Caribbean via shipping lanes from Africa (most probably Réunion), and since its introduction, the mite has spread widely through the islands of the Caribbean spreading northwards into Florida and southwards into Venezuela. Welbourn (2006) stated that the spread of the mite throughout the islands of the Caribbean may have been facilitated by the transport of infested plants and handicrafts made from palm material. Welbourn also stated that the natural dispersal method of the mite on wind currents may also be aided by tropical storms or hurricanes.

Risk of Introduction

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Authorities in the USA and Europe have carried out a risk assessment to identify the potential threat posed by *R. indica* and to model its future spread throughout palm-growing regions. A USDA risk assessment (Borchert, 2007) indicates that the spread of the mite may be limited by climatic factors, therefore limiting it to tropical and sub-tropical regions. Recommendations from the report were that movement of infested material should be restricted and not distributed to uninfested areas. This includes the transport of palm handicrafts between islands in the Caribbean. The USDA-APHIS and the Florida Department of Agriculture and Consumer Services have carried out surveys throughout Florida and have set up sentinel sites to monitor the spread of *R. indica* (Smith and Dixon, 2008). Literature was also produced in 2007 outlining the symptoms of infestation and a description of *R. indica.* In Europe, EPPO has produced a report citing that more data would be required on infestations in Israel and Egypt, and that currently there are no indications of the mite disseminating or causing high levels of damage. Vásquez et al.(2008) stated that quarantine measures have been implemented by SASA to prevent the further spread of *R. indica* to other parts of Venezuela; however, the mite has since been reported in Brazil (Navia et al., 2010) and Mexico (Estrada-Venegas et al., 2010).

Habitat

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In literature originating from the Old World prior to the introduction of the mite to the Caribbean, the host plants reported were *Cocos nucifera, Areca catechu, Phoenix dactylifera* (date palms) and *Dictyosperma album.* Since the introduction into the Caribbean, the number of host plants reported has increased substantially, most notably bananas [*Musa* sp.], plantains (*Musa* sp.) and other members of the order Zingiberales. It is not known whether these plants are unreported hosts in the Old World, or whether the host range has expanded in the invasive range. There are several new associations reported on hosts believed to have origins in the New World.

Habitat List

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Category	Sub-Category	Habitat	Presence	Status
Terrestrial	Terrestrial – Managed	Managed forests, plantations and orchards	Present, no further details	Harmful (pest or invasive)

Hosts/Species Affected

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The Host Plant list in this datasheet is compiled from Cocco and Hoy (2009) and Goldsmith (2009). It is noted in Cocco and Hoy (2009) that there is often no information on the life stage found on the host plant and therefore the list reflects which host plant species *R. indica* has been recorded on. Population levels on each of the host plants have not been recorded/published to date; therefore data on the ability of *R. indica* to complete a full lifecycle on each species is not available currently. In Cocco and Hoy (2009), laboratory assays to ascertain this on several varieties of *Musa sp.* were carried out and it was found that populations were more easily established on *Cocos nucifera.* However, reports from the eastern Caribbean confirm that multi-generational colonies do occur in the field on certain varieties of *Musa sp.* including Dwarf Cavendish, Giant Cavendish, Robusta and Williams, and for plantain varieties: Apem; Cents Livre; Ordinary; Dwarf French; and Horn. The difference between laboratory and field observations warrants further investigation.

Host Plants and Other Plants Affected

Plant name	Family	Context
Acer (maples) (/cpc/datasheet/2800)	Aceraceae	Other
Acoelorrhaphe wrightii (Everglades palm) (/cpc/datasheet/2768)	Arecaceae	Wild host
Adonidia arecina (/cpc/datasheet/109763)	Arecaceae	Wild host
Aiphanes minima (/cpc/datasheet/109764)	Arecaceae	Wild host
Alpinia purpurata (red ginger) (/cpc/datasheet/4377)	Zingiberaceae	Wild host
Alpinia vittata (/cpc/datasheet/109800)	Zingiberaceae	Wild host
Alpinia zerumbet (shell ginger) (/cpc/datasheet/109799)	Zingiberaceae	Wild host
Archontophoenix alexandrae (/cpc/datasheet/6726)	Arecaceae	Wild host
Areca catechu (betelnut palm) (/cpc/datasheet/6981)	Arecaceae	Main
Arenga pinnata (sugar palm) (/cpc/datasheet/3568)	Arecaceae	Wild host
Bactris plumeriana	Arecaceae	Wild host
Beccariophoenix madagascariensis (/cpc/datasheet/109766)	Arecaceae	Wild host
Bismarckia nobilis (/cpc/datasheet/9226)	Arecaceae	Wild host
Butia capitata (/cpc/datasheet/10462)	Arecaceae	Wild host
Calathea arundinacea (variegated calatea) (/cpc/datasheet/109925)	Marantaceae	Wild host
Calathea lutea (calathea) (/cpc/datasheet/109806)	Marantaceae	Wild host
Caryota mitis (/cpc/datasheet/11581)	Arecaceae	Wild host
Chamaedorea (/cpc/datasheet/14344)	Arecaceae	Wild host
Coccothrinax argentata (/cpc/datasheet/109767)	Arecaceae	Wild host
Coccothrinax miraguama (/cpc/datasheet/109768)	Arecaceae	Wild host
Cocos nucifera (coconut) (/cpc/datasheet/11788)	Arecaceae	Main
Corypha umbraculifera (/cpc/datasheet/15320)	Arecaceae	Wild host
Curcuma longa (turmeric) (/cpc/datasheet/17014)	Zingiberaceae	Wild host
Cycas (/cpc/datasheet/11832)	Cycadaceae	Other
Cyrtostachys renda (/cpc/datasheet/109770)	Arecaceae	Wild host
Dictyosperma album (/cpc/datasheet/18808)	Arecaceae	Main
Dypsis decaryi (/cpc/datasheet/109771)	Arecaceae	Wild host
Dypsis lutescens (/cpc/datasheet/109772)	Arecaceae	Wild host
Elaeis guineensis (African oil palm) (/cpc/datasheet/20295)	Arecaceae	Wild host
Elaeodendron transvaalense	Salacia	Wild host
Etlingera elatior (torch ginger) (/cpc/datasheet/109802)	Zingiberaceae	Wild host
Eucalyptus deglupta (kamarere) (/cpc/datasheet/22622)	Myrtaceae	Wild host
Eugenia uniflora (Surinam cherry) (/cpc/datasheet/23099)	Myrtaceae	Wild host
Heliconia (/cpc/datasheet/26639)	Heliconiaceae	Main
Heliconia bihai (macaw flower) (/cpc/datasheet/109790)	Heliconiaceae	Wild host
Heliconia caribaea (/cpc/datasheet/26640)	Heliconiaceae	Wild host
Heliconia caribaea x bihai (/cpc/datasheet/109791)	Heliconiaceae	Wild host
Heliconia chartacea (/cpc/datasheet/109793)	Heliconiaceae	Wild host
Heliconia episcopalis (/cpc/datasheet/109794)	Heliconiaceae	Wild host
Heliconia latispatha (/cpc/datasheet/109795)	Heliconiaceae	Wild host
Heliconia marginata (/cpc/datasheet/109796)	Heliconiaceae	Wild host
Heliconia psittacorum (/cpc/datasheet/26641)	Heliconiaceae	Wild host
Heliconia rostrata (/cpc/datasheet/109792)	Heliconiaceae	Wild host
Latania lontaroides (/cpc/datasheet/109773)	Arecaceae	Wild host
Licuala grandis (/cpc/datasheet/30714)	Arecaceae	Wild host
Licuala spinosa (/cpc/datasheet/109774)	Arecaceae	Wild host
Livistona chinensis (Chinese fan palm) (/cpc/datasheet/31059)	Arecaceae	Wild host
Microcycas calocoma	Zamiaceae	Other
Musa (banana) (/cpc/datasheet/35124)	Musaceae	Main

Plant name	Family	Context
Musa acuminata (wild banana) (/cpc/datasheet/35125)	Musaceae	Main
Musa balbisiana (/cpc/datasheet/35126)	Musaceae	Main
Musa corniculata (/cpc/datasheet/109776)	Musaceae	Wild host
Musa ornata (flowering banana) (/cpc/datasheet/109778)	Musaceae	Wild host
Musa uranoscopos (/cpc/datasheet/109775)	Musaceae	Wild host
Ocimum basilicum (basil) (/cpc/datasheet/36858)	Lamiaceae	Wild host
Pandanus utilis (/cpc/datasheet/38450)	Pandanaceae	Wild host
Phaseolus (beans) (/cpc/datasheet/40612)	Fabaceae	Wild host
Phoenix canariensis (Canary Island date palm) (/cpc/datasheet/40697)	Arecaceae	Wild host
Phoenix dactylifera (date-palm) (/cpc/datasheet/40698)	Arecaceae	Main
Phoenix reclinata (senegal date palm) (/cpc/datasheet/40705)	Arecaceae	Wild host
Phoenix roebelenii	Arecaceae	Wild host
Phoenix rupicola (/cpc/datasheet/109779)	Arecaceae	Wild host
Pritchardia pacifica (/cpc/datasheet/109780)	Arecaceae	Wild host
Pritchardia vuylstekeana (/cpc/datasheet/109781)	Arecaceae	Wild host
Pseudophoenix vinifera	Arecaceae	Wild host
Ptychosperma elegans (/cpc/datasheet/109782)	Arecaceae	Wild host
Ptychosperma macarthurii (Macarthur palm) (/cpc/datasheet/45714)	Arecaceae	Wild host
Ravenala madagascariensis (/cpc/datasheet/109798)	Strelitziaceae	Wild host
Renealmia alpinia (/cpc/datasheet/109804)	Zingiberaceae	Wild host
Renealmia aurantifera (/cpc/datasheet/109805)	Zingiberaceae	Wild host
Rhapis excelsa	Arecaceae	Wild host
Roystonea borinquena (/cpc/datasheet/109783)	Arecaceae	Wild host
Sabal blackburniana	Arecaceae	Wild host
Sabal mauritiiformis (/cpc/datasheet/109784)	Arecaceae	Wild host
Schippia concolor	Arecaceae	Wild host
Schippia concolor	Arecaceae	Wild host
Strelitzia reginae (Queens bird-of-paradise) (/cpc/datasheet/52050)	Strelitziaceae	Wild host
Syagrus romanzoffianum (queen palm) (/cpc/datasheet/109785)	Arecaceae	Wild host
Syagrus schizophylla (/cpc/datasheet/109786)	Arecaceae	Wild host
Thrinax radiata (/cpc/datasheet/53708)	Arecaceae	Wild host
Veitchia arecina (/cpc/datasheet/109787)	Arecaceae	Wild host
Veitchia merrillii (christmas palm) (/cpc/datasheet/56193)	Arecaceae	Wild host
Washingtonia filifera (desert fanpalm) (/cpc/datasheet/56706)	Arecaceae	Wild host
Washingtonia robusta (mexican washington-palm) (/cpc/datasheet/56708)	Arecaceae	Wild host
Wodyetia bifurcata (foxtail palm) (/cpc/datasheet/109789)	Arecaceae	Wild host
Zingiber (ginger) (/cpc/datasheet/57534)	Zingiberaceae	Wild host

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Growth Stages

Flowering stage, Fruiting stage, Seedling stage, Vegetative growing stage

Symptoms

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The presence of colonies of *R. indica* on leaflets or leaves initially causes localized yellowing, which may spread to form larger chlorotic patches. This can result in yellowing of the leaflet and potentially necrosis. In general, lower leaflets of palms are more severely affected and may appear yellow in colour. Infestations on bananas [*Musa paradisiaca*] and plantain often cause yellowing along the margins of the leaf (USDA-APHIS, 2007). On coconuts [*Cocos nucifera*] in the Caribbean it has been reported that flowers and small nuts may abort following the yellowing of the leaflets. Young seedlings appear to be most affected and the fronds most affected by the mite are generally in the lower third of the canopy (Hoy et al., 2006). Peña et al. (2009) stated that heavy infestations may result in death of young plants.

List of Symptoms/Signs

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Sign	Life Stages	Type
Fruit / premature drop		
Leaves / abnormal colours		
Leaves / external feeding		
Leaves / necrotic areas		
Leaves / yellowed or dead		
Whole plant / discoloration		
Whole plant / external feeding		

Biology and Ecology

Genetics

R. indica is a haplo-diploid bisexual species confirmed by the presence of two classes of eggs; one class containing two chromosomes and one class containing four chromosomes (Helle et al., 1972). Little information is known about the genetic diversity of the species. Dowling et al. (2010) carried out a biogeographical study of *R. indica* and discovered that the most primitive haplotypes tended to be found in the Middle East.

Reproductive Biology

The life history of *R. indica* was described by Moutia (1958) and Zaher et al. (1969) on *Cocos nucifera* (coconut) and *Phoenix dactylifera,* respectively. The eggs are laid in groups, often near the midrib or depressions in the leaflet, and on hatching, the larvae emerge and start feeding on leaf tissue. The number of eggs laid varies from individual to individual; however, Moutia (1958) recorded that on average, 28.1 eggs were laid on leaf discs during the average adult female life span of 27 days. As the larvae and nymphs pass through each stage, they enter a quiescent stage for 36-48 hours, whereby they enter ecdysis and withdraw posteriorly from the exuviae (Zaher et al., 1969). The duration of each stage on coconut at 24.2°C in Mauritius was egg: 4-6 days; larva: 6-8 days; protonymph: 4-7 days; deutonymph: 4-5 days; however, the duration of stages increases with lower average temperatures (Moutia, 1958). Hoy et al. (2006) highlighted findings by Nageshachandra and ChannaBasavanna (1984), stating that both mated and unmated females lay eggs, with males emerging from the eggs laid by unmated females and the eggs from mated females emerging as female.

Physiology and Phenology

No studies to date (2010) have been carried out on this subject.

Nutrition

Studies on the nutritional requirements of *R. indica* have not been carried out; however, a study was conducted looking at the correlation of leaf nutrients to *R. indica* populations. Sarkar and Somchoudhury (1989b) investigated correlations of mite populations in association with crude protein, nitrogen, moisture, calcium and phosphorus content of coconut leaflets. They found that coconut varieties with higher levels of nitrogen and crude protein had higher population densities of the mite; no significant effect of calcium or phosphorus content was found in association with mite incidence. They reported that varieties of coconut with higher moisture content in leaflets were more susceptible to herbivory by *R. indica;* however, other reports suggest that poorly irrigated host plants are more susceptible to attack by the mite (Devasahayam and Nair, 1982).

Environmental Requirements

The exact range of tolerance of temperature is unknown; however, Sarkar and Somchoudhury (1989a) showed that as temperatures peak toward 40°C in West Bengal, populations of *R. indica* also peak. Yadavbabu and Manjunatha (2007) also reported that populations on *Areca catechu* were positively correlated to temperature, with highest average populations recorded alongside the highest maximum temperature at 39.9°C. Data consistently shows that populations build up in hot dry conditions and reduce with the onset of the monsoon in the Old World (Moutia, 1958; Daniel, 1979; Sarkar and Somchoudhury, 1989a; Sathiamma, 1996; Yadavbabu and Manjunatha, 2007). Yadavbabu and Manjunatha (2007) reported a negative correlation between mite populations and rainfall and humidity, and Moutia (1958) noted a decline in populations with the onset of heavy rain. Sarkar and Somchoudhury (1989a) found no relationship between rainfall and mite population size. A recent paper by Carillo et al. (2010) described the successful culture of *R. indica* at 30°C (±1°C), 60% (± 5%) RH and a 12:12 L:D photophase on the abaxial leaflet of Malayan Dwarf coconut palms [*Cocos nucifera*].

Notes on Natural Enemies

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Several studies have been conducted to identify natural enemies of *R. indica*. As a mite, all the natural enemies recorded have been predators including phytoseiid mites, Coccinellids, Staphylinids, Neuropterans, Dipterans and Thysanopterans. Several studies have been carried out in the field to observe the levels of natural enemies in comparison to those of *R. indica*, as well as laboratory studies to assess the voracity of the predators.

Moutia (1958) carried out a comprehensive survey of natural enemies in Mauritius and recorded that *Typhlodromus caudatus* was an active predator of *R. indica* during the study. The mite reportedly predated on the egg stage, feeding on up to five to six mites successively and up to a maximum of 16.9 in a day. The predator was found in high abundance on coconut [*Cocos nucifera*] leaflets.

Somchoudhury and Sarkar (1989) carried out a study in West Bengal, India, and found the predominant predators to be a staphylinid beetle, *Oligota sp.* and two predatory mites, *Phytoseius sp* and *Amblyseius sp. Oligota sp. and Phytoseius sp.* showed a correlation in population growth with *R. indica* throughout the season. In Karanataka, India, the predatory mite, *Amblyseius channabasavanni* and the coccinellid, *Stethorus keralicus* have been reported to prey upon *R. indica* and biological studies have shown that *S. keralicus* can feed and reproduce solely on a diet of *R. indica*, completing development from egg to adult in 12-14 days, feeding on all stages of the mite (Daniel, 1976).

The most abundant predators of *R. indica* appear to be phytoseiid mites. A recent study by Taylor et al. (CABI, UK, paper in preparation 2011) in Kerala, India, found that by far the most abundant predators were phytoseiid mites (IDs underway 2009) and from the literature, the most widely reported genus of predator is *Amblyseius.* Daniel (1981, cited in Gupta, 2003) reported that *A. channabasavanni,* feeding on *R. indica* eggs, had a total development time of 84-113hrs (3.5-4.7 days) for adult females, consuming on average 26.5 eggs. *Amblyseius largoensis* has also frequently been reported in association with *R. indica* in countries such as Mauritius (MA Hoy, [address available from CABI], personal communication, 2009) and throughout the Caribbean and Florida (Hosein, 2008; Peña et al., 2009).

In Florida, a study has been carried out to assess the response of native natural enemies to the introduction of the mite. Several species have been shown to be associated with *R. indica,* but by far the most abundant predator was found to be *A. largoensis,* which accounted for 77.2% of total predators collected in a study by Peña et al. (2009) followed by *Aleurodothrips fasciapennis*. Subsequent laboratory studies by Carrillo et al. (2010) have shown that *A. largoensis* can feed and reproduce solely on *R. indica.*

Natural enemies

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Natural enemy	Type	Life stages	Specificity	References	Biological control in	Biological control on
Aleurodothrips fasciapennis (/cpc/datasheet/4119)	Predator	Adults/Eggs/Nymphs				
Amblyseius channabasavanni (/cpc/datasheet/4741)	Predator			Daniel, 1979		
Amblyseius largoensis (/cpc/datasheet/4760)	Predator	Adults/Eggs/Nymphs		Carrillo et al., 2011		
Amblyseius longispinus (/cpc/datasheet/109752)	Predator			Gupta, 2003		
Amblyseius raoiellus (/cpc/datasheet/109753)	Predator			Gupta, 2003		
Armascirus taurus (/cpc/datasheet/6989)	Predator					
Bdella distincta (/cpc/datasheet/109760)	Predator					
Ceraechrysa (/cpc/datasheet/109759)	Predator					
Chrysopa (/cpc/datasheet/16448)	Predator			Daniel, 1979		
Chrysoperla (/cpc/datasheet/13182)	Predator					
Cunaxidae (/cpc/datasheet/750)	Predator					
Cybocephalus semiflavus (/cpc/datasheet/109757)	Predator			Daniel, 1979		
Evorinea indica (/cpc/datasheet/109924)	Predator					
Feltiella (/cpc/datasheet/24261)	Predator			Daniel, 1979		
Jauravia soror (/cpc/datasheet/29247)	Predator			Daniel, 1979		
Oligota (/cpc/datasheet/37253)	Predator			Somchoudhury and Sarkar, 1989		
Phytoseius (/cpc/datasheet/45644)	Predator			Somchoudhury and Sarkar, 1989		
Spilocaria bissellata (/cpc/datasheet/50960)	Predator			Daniel, 1979		
Stethorus keralicus (/cpc/datasheet/51958)	Predator			Daniel, 1976; Daniel, 1979; Kapur, 1961; Puttaswamy and Rangaswamy, 1976		
Stethorus parcepunctatus (/cpc/datasheet/109756)	Predator			Daniel, 1979		
Stethorus tetranychi (/cpc/datasheet/109755)	Predator			Daniel, 1979		
Stethorus utilis (/cpc/datasheet/109761)	Predator					
Telsimia ephippiger (/cpc/datasheet/109758)	Predator					
Typhlodromus caudatus (/cpc/datasheet/109754)	Predator			Moutia, 1958		

Means of Movement and Dispersal

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Natural Dispersal (Non-Biotic)

Welbourn (2006) stated that wind dispersal was the most likely method of natural dispersal, and Hoy et al. (2006) stated that the presence of mites on older palms on islands adjacent to Martinique within a year of introduction, indicate that wind dispersal was the primary dispersal method.

Accidental Introduction

It is believed that *R. indica* was first accidentally introduced to the Caribbean via infested material imported via shipping lanes from the Old World. No research to date has identified whether this was a single or multiple introduction. Accidental spread to new areas is via the introduction of infested plants or plant material or via palm handicrafts infested with mites or eggs (Welbourn, 2006), which are common tourist souvenirs and readily transported. Quarantine measures are in place to prevent the transfer of mites via palm handicrafts, cut flower and leaf arrangements from host plants and coconut seed.

Pathway Causes

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Cause	Notes	Long Distance	Local	References
Cut flower trade	Phytosanitary certificates required when transported between Caribbean islands		Yes	
Garden waste disposal	Investigated as one of the pathways in Florida		Yes	
Nursery trade	PPQ Plant Inspection required for untreated shipments in N. Atlantic/N.Pacific ports, USA	Yes		
Ornamental purposes	Dept. of Homeland Security Custom and Border Control found palm handicrafts to carry eggs and adults		Yes	
Seed trade	Coconut seed found to carry R. indica when transported between regions	Yes	Yes	

Pathway Vectors

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Vector	Notes	Long Distance	Local	References
Consumables	On palm handicrafts between islands in the Caribbean		Yes	
Mulch, straw, baskets and sod	On palm handicrafts between islands in the Caribbean		Yes	
Plants or parts of plants	On palm handicrafts between islands in the Caribbean & on cut flower & host plant leaf arrangements	Yes	Yes	
Wind	Thought to aid dispersal locally or between islands in the Caribbean	Yes	Yes	Hoy et al., 2006

Plant Trade

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Plant parts liable to carry the pest in trade/transport	Pest stages	Borne internally	Borne externally	Visibility of pest or symptoms
Fruits (inc. pods)			Yes	Pest or symptoms usually visible to the naked eye
Leaves	adults; eggs; larvae; nymphs		Yes	Pest or symptoms usually visible to the naked eye
Seedlings/Micropropagated plants	adults; larvae; nymphs		Yes	Pest or symptoms usually visible to the naked eye
Stems (above ground)/Shoots/Trunks/Branches	adults; larvae; nymphs		Yes	Pest or symptoms usually visible to the naked eye

Plant parts not known to carry the pest in trade/transport
Bark
Bulbs/Tubers/Corms/Rhizomes
Flowers/Inflorescences/Cones/Calyx
Growing medium accompanying plants
Roots
True seeds (inc. grain)
Wood

Impact Summary

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Category	Impact
Cultural/amenity	Negative
Economic/livelihood	Negative
Environment (generally)	Negative

Impact: Economic

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Little empirical data has been gathered on the economic impact of the introduction of *R. indica* to the Caribbean, USA and South America. Peña et al. (2009) quoted that coconut [*Cocos nucifera*] growers have reported a 70% drop in coconut production since the introduction of the mite and FAO figures have shown a drop to date in coconut production from Caribbean countries since 2004, when the mite was first identified in the region. Empirical studies are required to confirm these figures/correlations; however, officials are concerned that this may lead to job losses and major socio-economic problems. In Florida, it was feared possible economical impacts could come from quarantine restrictions if *R. indica* was detected in palm nurseries. However, Bronson (2009) stated that *R. indica* population levels were lower than expected in Florida and quarantine would not to be enforced unless infestation levels were found to be high. Extra costs for implementing regulatory actions in Florida have been quoted to be as much as half a million US dollars extra per year for palm nursery producers (Peña et al., 2009).

Impact: Environmental

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Impact on habitats

The amenity value of many ornamental plants and palms is severely affected by the yellowing that the mite causes.

Risk and Impact Factors

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Invasiveness

- Proved invasive outside its native range
- Abundant in its native range
- Is a habitat generalist
- Tolerant of shade
- Capable of securing and ingesting a wide range of food
- Fast growing
- Has high reproductive potential
- Reproduces asexually

Impact outcomes

- Host damage
- Negatively impacts forestry
- Reduced amenity values
- Damages animal/plant products
- Negatively impacts trade/international relations

Impact mechanisms

- Rapid growth

Likelihood of entry/control

- Highly likely to be transported internationally accidentally
- Difficult to identify/detect as a commodity contaminant
- Difficult to identify/detect in the field
- Difficult/costly to control

Detection and Inspection

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Colonies of *R. indica* are usually found on the underside of leaves/leaflets of the host plants. Colonies often contain mites of all stages as well as exuvial remains (white cast skins) and can have up to 300 individuals (Kane and Ochoa, 2006). Inspection of the underside of leaflets of host plants using a hand lens, or removal of material and inspection under a dissecting microscope can confirm the presence of mites (Hoy et al., 2006). Affected host plants will generally display symptoms under heavy infestations. Typical damage symptoms include localized yellowing of the leaf, which can spread into larger chlorotic patches. Heavy infestations may be found along the midrib of coconut leaflets and damage may progress from localized yellowing to necrosis (Rodríguez et al., 2007). Infestations on bananas [*Musa paradisiaca*] and plantain often cause yellowing along the margins of the leaf (USDA-APHIS, 2007). If there are heavy infestations, persons inspecting the host plant may find they pick up red on their fingers from the mites on the underside of leaves.

A diagnostic Lucid key to 20 species of *Raoiella* is available in Flat Mites of the World (http://idtools.org/id/mites/flatmites/).

Similarities to Other Species/Conditions

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R. indica may be distinguished from other red mites on hosts as it is found in colonies that lack the webbing associated with spider mites (Tetranychidae). Other distinguishing features are the presence of white cast skins among the colony, red legs, long dorsal setae (often with droplets of liquid on) and flattened bodies (Kane and Ochoa, 2006; Welbourn, 2006). Couplets may be observed between the male and females in most colonies. Couplets are formed between the male and the female deutonymph as the female moults to adult and *R. indica* is the only species of Tetranychoid mite to display this behaviour (Welbourn, 2006). Damage symptoms can be confused with nutrient deficiency or the disease, Lethal Yellowing (USDA-APHIS, 2007). Zaher et al. (1969) stated that damage caused by *R. indica* could be distinguished from that caused by another leaflet infesting mite, *Phyllotetranychus aegyptiacus*, as *R. indica* causes ‘dark reddish blotches’ to appear on date palms [*Phoenix dactylifera*]; whereas the other species cause ‘dirty white’ patches.

Prevention and Control

Public Awareness

USDA have produced public awareness leaflets (USDA-APHIS, 2007) highlighting the signs and symptoms to look out for and which authorities to contact in the case of the presence of the mite. Red palm mite updates and guidelines are available at http://www.doacs.state.fl.us/pi/enpp/ento/red_palm_mite.html (http://www.doacs.state.fl.us/pi/enpp/ento/red_palm_mite.html).

Movement Control

Quarantine measures are in place to restrict the movement of infested material. For example, the movement of palm handicrafts, cut flowers, etc, in the Caribbean. In Florida, there is no longer mandatory quarantine for infested palms; however, quarantine measures are enforced if population levels increase (Bronson, 2009). Host palms originating from infested countries are not permitted entry into the USA without a phytosanitary certificate. In addition, palm handicrafts are not permitted to enter Florida.

Biological Control

Biological control is seen as the best way to tackle the introduction of the mite, due to its widespread presence throughout the Caribbean and now Florida and South America. Chemical control is difficult as palms can grow incredibly tall and are difficult to treat. Several routes of biological control are being investigated. Peña et al. (2009) have investigated the response of native and commercially-produced predators to the introduction of *R. indica* into Florida. Predator density was observed to increase 6 months after the introduction of *R. indica* into Florida with the most common association found to be with *Amblyseius largoensis*. Laboratory studies by Carrillo et al. (2010) have shown that *A. largoensis* can play a role in controlling *R. indica* in Florida, and observations from the field have shown this predator to increase in density on introduction of *R. indica* to the area (Peña et al., 2009). *A. largoensis* has been reported in association with *R. indica* in several of the countries where the mite is invasive, including Puerto Rico, Trinidad and Tobago (Peña et al., 2009), and Cuba (Ramos-Lima et al., 2010). Interest has arisen in the possibility of classical biological control due to the abundance of predators reported in the Old World. Preliminary investigations by CABI (B Taylor, CABI, 2009, personal observation) into the possibility of classical biological control have been funded by USDA. The study has looked at the abundance of predators associated with *R. indica* in India, and studies have confirmed that phytoseiid mites are the most commonly-occurring predator associated with the mite (species ID underway). However, suitability as biological control agents has not been investigated and further research is required before the importation of an exotic predator would be possible.

Chemical Control

Several trials have been carried out in India regarding the control of *R. indica,* the most recent including Nadarajan et al. (1980); Sarkar and Somchoudhury (1988); Jalaluddin and Mohanasundaram (1990); Senapati and Biswas (1990) and Jayaraj et al. (1991). Nadarajan et al. (1980) tested several compounds including the systemic pesticides dimethoate and formothion, which were applied through stem injection; results showed that all treatments significantly reduced *R. indica* numbers. The most recent trials have been carried out by Peña et al. (2008), and Peña and Rodrigues (2010) in Florida and Puerto Rico. Results showed significant reduction in mite density for several chemicals including spiromesifen, dicofol, acequinocyl and etoxazole. Sarkar and Somchoudhury (1988) reported 69.2% mortality with dicofol in India. Peña and Rodrigues (2010) tested further compounds and found that Sanmite [pyridaben] and Avid [avermectin] + Glacial gave the best results for keeping *R. indica* densities low on coconut seedlings and on bananas good control was observed using TetraSan [etoxazole] and acequinocyl. However, it is proposed that the best results for the control of *R. indica* will come from implementing an IPM programme. Acaricides that are currently available do not give 100% control of *R. indica* and a programme using chemicals to initially suppress high pest populations and the subsequent use of biological control agents to keep populations low is thought to be the best approach for control (Bronson, 2009).

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Links to Websites

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Website	URL	Comment
Detection & Identification of the red palm mite (Raoiella indica)	http://www.sel.barc.usda.gov/acari/PDF/indicaGuide.pdf (http://www.sel.barc.usda.gov/acari/PDF/indicaGuide.pdf)	
Florida Department of Agriculture & Consumer Services - Division of Plant Industry	http://www.doacs.state.fl.us (http://www.doacs.state.fl.us)	
GISD/IASPMR: Invasive Alien Species Pathway Management Resource and DAISIE European Invasive Alien Species Gateway	https://doi.org/10.5061/dryad.m93f6 (https://doi.org/10.5061/dryad.m93f6)	Data source for updated system data added to species habitat list.
USDA Program Aid no. 1935 - Look out for the red palm mite	http://www.aphis.usda.gov/publications/plant_health/content/printable_version/RedPalmMite_6-20-7.pdf (http://www.aphis.usda.gov/publications/plant_health/content/printable_version/RedPalmMite_6-20-7.pdf)	

Organizations

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USA: United States Department of Agriculture, 1400 Independence Avenue, Washingon DC 20250, www.usda.gov (www.usda.gov)

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World Map

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