

Nota Científica
(Short Communication)

CHILOCORUS CACTI (COLEOPTERA: COCCINELLIDAE), A POTENTIAL NATURAL ENEMY FOR THE RED PALM MITE IN MEXICO

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RESUMEN. *Raoiella indica* Hirst (Acari: Tenuipalpidae), el ácaro rojo de las palmas, es una plaga importante en el mundo, dañando plantas comerciales y ornamentales. En 2009 fue observada por primera vez en México y se extendió rápidamente. Puede ocasionar daños importantes a los cultivos y también ha infestado en reservas protegidas. Para limitar el uso de acaricidas, principalmente en áreas protegidas, se han buscado depredadores naturales. Globalmente se han identificado 28 depredadores incluyendo otros ácaros, insectos y hongos. En este estudio, presentamos una nueva especie nativa coccinélida, *Chilocorus cacti* (Linnaeus), como depredador potencial de *R. indica* en México. **Palabras clave:** *Chilocorus* spp. *Raoiella indica*. Código de barras. Invasión biológica. Quintana Roo.

The red palm mite, *Raoiella indica* Hirst, is a recent invasive species of the New World and although palm species (Arecales: Arecaceae) are its principal hosts, it also affects a wide range of alternative host plants (Carrillo *et al.* 2012a). It was first reported in India, infesting coconut palms, *Cocos nucifera* L. (Arecaceae) (Hirst 1924), and subsequently expanded its geographical range to Africa (Moutina 1958, Pritchard & Baker 1958, Gerson *et al.* 1983). The introduction of this particular pest species to the New World is a very recent event which commenced during the late 1990's in several French islands of the Caribbean (Flechtman *et al.* 1999). In 2004, it was detected in Martinique (Flechtman & Etienne 2004) before extending to other areas of the Caribbean (Etienne & Flechtman 2006, Rodriguez *et al.* 2007, Kane *et al.* 2012). In 2007 it was identified in Florida, United States (FDACS 2009) and has since spread very rapidly to parts of Central and South America (Vásquez *et al.* 2008, Marsaro *et al.* 2009, Carrillo *et al.* 2011). More recently (2009), *R. indica* was identified for the first time in Cancún and Isla Mujeres (state of Quintana Roo) in Mexico (NAPPO 2009). Now, this palm pest is found in many states of Mexico (Campeche, Chiapas, Jalisco, Nayarit, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatán; Senasica 2013) expanding rapidly throughout the country. The capacity of this pest to spread so quickly is alarming because it could

potentially infest a wide diversity of plants, many of which are economically and ecologically important (Carrillo *et al.* 2012a). In Mexico, 16 species of commercially grown plants (some of which form entire genus) belonging to four families (Arecaceae, Heliconiaceae, Musaceae and Strelitziaceae) have been reported as hosts of the red palm mite (Senasica 2013). In particular, four economically important plants in Mexico could be affected most by the red palm mite: three palm species (the African oil palm, *Elaeis guineensis* Jacq., the coconut palm, *Cocos nucifera* L., and the date palm, *Phoenix dactylifera* L.) and several banana species, *Musa* spp. (Senasica 2013).

To control the red palm mite, one alternative is the use of chemical control using acaricides, the other is biological control with natural enemies. Currently, many efforts are focused on identifying suitable natural enemies for use in pest control programs. Studies (in Carrillo *et al.* 2014) show that each geographical area presents a specific natural enemy complex, but all have one common predatory mite species, *Amblyseius largoensis* Muma (Acari: Phytoseiidae) (Carrillo *et al.* 2012b). In their review on natural enemies, Carrillo *et al.* (2012b) mention a total of 28 species of predatory arthropods, including mites and insects, and three species of pathogenic fungi reported in Puerto Rico. As well as *A. largoensis*, two coccinellids species were reported as important predators of *R. indica*: *Stethorus keralicus* Kapur in India, and *Telsimia ephippiger* Chapin (Coleoptera: Coccinellidae) in the Philippines (in Carrillo *et al.* 2014). Another coccinellid species, *Chilocorus cacti* L., is reported in India (Puttarudriah & Channabasavanna 1956) and in Florida, USA (in Carrillo *et al.* 2012b) through communication personal.

In Mexico, specific studies were conducted to identify local natural enemies (Senasica 2013) and it was considered that both predators of *R. indica* in Florida (*A. largoensis* and *S. keralicus*) could be potential predators in Mexico. Furthermore, in southern Mexico, the presence of *R. indica* in protected areas where chemical control is strictly prohibited is problematic, and local solutions using native natural enemies is required.

We present the first report identifying the species of *Chilocorus cacti*, using DNA barcoding and morphologi-

cal characteristics, as a potential native natural predator of the red palm mite in the state of Quintana Roo, Mexico.

Observations and collection of individuals were conducted in different areas of Quintana Roo (southeast Mexico): in the Sian Ka'an Biosphere Reserve, in the city of Chetumal (Quintana Roo), in Raudales and Laguna Guerrero (two localities approximately 30 km from Chetumal), and in the National Reef Park of Xcalak. In each one of those geographic areas we observed larvae and adults of *C. cacti* associated with coconuts palms, together with a severely infested leaf, full of *R. indica*. Individuals of *R. indica* and *C. cacti* (larvae and adults) were collected on the coconut palms and placed in a box for transportation to the laboratory for observation (adult specimens were deposited in the Zoological Museum of ECOSUR, Chetumal, Mexico). For the molecular analysis by DNA barcoding, legs from seven collected adults just after moulting were placed in a lysis plate well (96-well Eppendorf® Plates) with a drop of 96% ethanol. Genomic DNA was extracted from the legs and the extraction process was conducted following Montero-Pau *et al.* (2008). DNA amplification and sequencing were processed as for Prado *et al.* (2011). Sequences and all collateral data from specimens are available on the BOLD website (www.boldsystems.org) in the project entitled "Cacti". In addition, photos were taken of the adults using a Nikon D7000 camera with a 105 mm Micro-Nikkor lens and a Nikon Speedlight Flash SB-900.

The obtained DNA barcode allowed 99.51% identification to genus level: *Chilocorus*, using the BOLD-IDS tools. Many species of *Chilocorus* were registered in Boldsystems and BLAST® tool from GenBank but none matched our sequences. To obtain identification at species level were used dorsal and ventral photos (Fig. 1) of adults and different resources: a taxonomic key to identify species of *Chilocorus* (Gordon 1985) and two web sites that included an identification guide (<http://bugguide.net/> and <http://www.discoverlife.org/20/q?guide=Ladybug>). The cross checking of all available information allow to identify the species as *Chilocorus cacti*. Important characteristic for identification of *C. cacti* is the red or yellow ventral surface (except posternum), their large spot on elytron and its wide geographical distribution from southern part of USA to northern part of South America including Mexico and Caribbean islands.

The Coccinellidae, commonly referred as ladybirds, ladybugs or ladybeetles depending on the region, have been extensively studied as around 90% of species are beneficial predators against pest insects (Roy & Migeon 2010). In particular, *Chilocorus* species are recognized to be predators of a wide range of insect and mites pests on date palms in Iraq (Hussain 1974), citrus orchards in Iran (Hallaji-Sani *et al.* 2013), and kiwifruit in New Zealand (Charles *et al.* 1995) among others. Moreover, *Chilocorus* spp. are reported as predators of the cochineal, *Dactylopius coccus* Costa (Hemiptera: Dactylopiidae), used for



Figure 1. *Chilocorus cacti* (L.) in Quintana Roo, Mexico. A: dorsal view, B: ventral view.

the production of natural red dye in Oaxaca (Mexico) (Santiago & Meneses-Lozano 2010). In this particular case, *Chilocorus* spp. became a serious threat for the production of this precious dye. Overall, *Chilocorus cacti* has showed its efficacy as a biological control agent by controlling and maintaining low levels of infestation of

a large number of pests through the world (Pluke *et al.* 2005, Cave 2006, López-Arroyo *et al.* 2008, Ruiz *et al.* 2008, Fernández *et al.* 2010).

Mexico is a country with many agricultural products, for internal consumption or exportation, including avocado, coffee, lemon, orange, sugarcane, banana, etc. The

Table 1. A list of hemipteran and lepidopteran pests in Mexico where *Chilocorus cacti* has been reported as a natural predator and new record in Quintana Roo as predator in red pal mite.

Taxa	Scientific name	Common name	Host plant	Place of report	References
ACARI					
Tenuipalpidae	<i>Raoiella indica</i> Hirst	Red palm mite	Mainly Arecaceae	Quintana Roo*	Present work
INSECTA					
Hemiptera					
Coccidae	<i>Philephedra lutea</i> Cockerell	soft scale	Euphorbiaceae Juss. (ornamental)	Tamaulipas	Gaona-García <i>et al.</i> 2004
Dactylopiidae	<i>Dactylopius opuntiae</i> Cockerell	Cochineal	<i>Opuntia ficus-indica</i> Mill. (prickly pear cacti known as nopales)	Mexico	Vanegas-Rico <i>et al.</i> 2010 Flores <i>et al.</i> 2013
Diaspididae	<i>Abgrallaspis aguacatae</i> Evans, Watson and Miller	Armoured scales	<i>Persea americana</i> Miller (avocados var. Hass)	Michoacán	Lázaro-Castellanos <i>et al.</i> 2012
	<i>Acutaspis agavis</i> Townsend and Cockerell	agave scale	<i>Agave tequilana</i> Weber var. <i>azul</i>	Guanajuato	Salaz-Araisa <i>et al.</i> 2008
	<i>Aulacaspis tubercularis</i> Newstead	mango white scale	<i>Mangifera indica</i> L. (Mango)	Nayarit	Hernández-Fuentes <i>et al.</i> 2012
	<i>Chrysomphalus aonidum</i> (L.)	Florida citrus red scale	<i>Citrus</i> sp.	Almost all Mexico	Jiménez 1963 González <i>et al.</i> 2015
				Tamaulipas	Ruiz <i>et al.</i> 1998 Ruiz <i>et al.</i> 2006
	<i>Hemiberlesia lataniae</i> Signoret	Armoured scale	<i>Persea americana</i> Miller (avocados var. Hass)	Michoacán	Lázaro-Castellanos <i>et al.</i> 2012
	<i>Hemiberlesia rapax</i> Comstock	Armoured scale	<i>Persea americana</i> Miller (avocados var. Hass)	Michoacán	Lázaro-Castellanos <i>et al.</i> 2012
	<i>Parlatoria pseudaspidotus</i> Linndinger	Armoured scale	<i>Mangifera indica</i> L.	Sinaloa	Cortez-Mondaca 2008 Cortez-Momdaca <i>et al.</i> , 2008
	<i>Unaspis citri</i> (Comstock)	Citrus snow scale	<i>Citrus</i> sp.	Colima	Coronado <i>et al.</i> 2006 Coronado <i>et al.</i> 2008
	<i>Diaphorina citri</i> Kuwayama	Asian citrus psyllid	<i>Citrus</i> spp. L.	Nayarit	Rodríguez-Palomera <i>et al.</i> 2012
Psyllidae				Tamaulipas	Gaona <i>et al.</i> 2009 Sánchez <i>et al.</i> 2015
				Veracruz	Murillo <i>et al.</i> 2010 Ortega-Arenas <i>et al.</i> 2013
				Yucatán	Lozano-Contreras & Jasso-Argumedo 2012
Lepidoptera					
Noctuidae	<i>Spodoptera frugiperda</i> (J.E. Smith)	Fall armyworm	<i>Zea mays</i> L.	Durango	García-Castro 1988 Bahena & Cortez 2015

* New record in Mexico in the association host-predator.

diverse mosaic of habitats in Mexico, provides suitable conditions for many palm species (Fonseca 1999) that are exploited for agricultural or ornamental purposes. All of these species are hosts to a wide range of insects or mite pests; therefore numerous studies have been carried out to find alternative solutions to the application of chemical products, including the use of natural predators. The coccinellid, *Chilocorus cacti*, is used as biological control agent on a wide range of plants in Mexico (Table 1).

As far as we know, *C. cacti* has never been reported as a pest predator for any species of palm, whether ornamental or commercial, in Mexico. This paper reports for the first time, the presence of *C. cacti* (adult and larval) on coconut palms infested by *R. indica* in Quintana Roo (Mexico). The global economic loss caused by the *R. indica* mite is significant. In Mexico, there are 147,000 ha of banana, coco, palm oil and date palm orchards, all principal crop hosts of this pest (Senasica 2013). Furthermore, the reports of extensive damage throughout the world, suggest that the impact of *R. indica* could be devastating. Additionally, considering the presence of *R. indica* in ecological reserves as Sian Ka'an and Xcalak, where the use of acaricides is prohibited, the alternative method of exploiting a native natural predator to control this pest is an appropriate solution that merits further study. Therefore, more research, in order to evaluate the efficacy and rearing possibilities of this natural predator, is required.

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