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What is the southern limit of the distribution of red palm mite, *Raoiella indica* (Acari: Tenuipalpidae), in agricultural lands in Brazil?

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Abstract

The red palm mite, *Raoiella indica* Hirst (Acari: Tenuipalpidae), has been considered one of the most threatening pests of coconut, banana, and other monocotyledonous plants. It now has been reported from several Brazilian states, but little is known about its current distribution in the southern half of Brazil. The objective of this study was to evaluate the distribution of *R. indica* and the associated predatory mites in mid-southern Brazil, and to determine the possible southern limit to its distribution in the country. It was found in the Federal District and in 49 municipalities of 9 states, of which the southernmost was Iporã, Paraná State (24.007222°S, 53.698333°W). The majority of the surveyed sites south of Iporã had higher altitude than this municipality and surveyed sites immediately north of it. Thus, sites south of Iporã seem ecologically unsuitable to *R. indica*, most probably because of the low temperature in the winter. Eighteen species of predatory mites were found in association with *R. indica*, all of which belong to the order Mesostigmata, and 14 of which belong in the family Phytoseiidae. However, they are not *R. indica*-specific, as most have been reported from coconut (and other plants) in Brazil and elsewhere, regardless of the occurrence of *R. indica*.

Key Words: phytoseiid mites; natural enemies; coconut

Resumo

Raoiella indica tem sido considerada uma das pragas mais importantes de coqueiro, bananeira e plantas de importância florística. Atualmente foi relatado em vários estados brasileiros, mas pouco se sabe sobre sua distribuição atual no sul do Brasil. O objetivo deste estudo foi avaliar a distribuição de *R. indica* e os ácaros predadores associados no centro-sul do Brasil, discutindo o possível limite sul de sua distribuição. *Raoiella indica* foi encontrado no Distrito Federal e em 49 municípios de 9 estados, dos quais o mais meridional foi Iporã, estado do Paraná (24.007222°S, 53.698333°W). A maioria dos pontos pesquisados ao sul de Iporã tem altitude maior do que este município e dos pontos pesquisados imediatamente ao norte. Assim, pontos ao sul Iporã parecem ecologicamente inadequadas para *R. indica*, muito provavelmente por causa da baixa temperatura no inverno. Dezoito espécies de ácaros predadores foram encontradas em associação com *R. indica*, todos dos quais pertencentes à ordem Mesostigmata e 14 pertencem a família Phytoseiidae. No entanto, eles não são inimigos naturais específicos de *R. indica*, pois, a maioria foi relatada em coqueiro (e outras plantas) no Brasil e em outros lugares, independentemente da ocorrência de *R. indica*.

Palavras Chave: Ácaros fitoseídeos; inimigos naturais; coqueiro

The red palm mite, *Raoiella indica* Hirst (Acari: Tenuipalpidae), is considered one of the most threatening pests of coconut, banana, and other monocotyledonous plants on the American continent and in the Caribbean region (Etienne & Flechtmann 2006; Carrillo et al. 2011a; Navia et al. 2015). Infested leaves usually become yellowish, with the attacked area drying as the population grows (Flechtmann & Etienne 2004; Peña et al. 2006). Plants are more seriously affected when infestations are associated with water stress and malnutrition (Navia et al. 2015).

Raoiella indica was first reported from the Western Hemisphere in the mid 2000s (Flechtmann & Etienne 2004), spreading since then to extensive areas in the tropical and subtropical regions of the American continent and the Caribbean (Welbourn 2006; Rodrigues et al. 2007; Vásquez et al. 2008; Carrillo et al. 2011b; Kane et al. 2012). Since its first report in Brazil in 2009, in the state of Roraima (Navia et al. 2011), new records were published from the states of Amazonas (Rodrigues & Antony 2011), São Paulo (Oliveira et al. 2016), Paraná (Hata et al. 2017), Alagoas, Bahia, Ceará, Distrito Federal, Goiás, Maranhão, Minas

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Gerai, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe (Melo et al. 2018). The risk of establishment of this mite in different parts of Brazil has been evaluated by Amaro & Morais (2013), although knowledge about the distribution of this mite in the southern half of the extensive Brazilian territory is still limited (Oliveira et al. 2016; Hata et al. 2017).

Coconut, *Cocos nucifera* L. (Arecaceae), is the principal host of *R. indica* (Carrillo et al. 2011a; Navia et al. 2015; Otero-Colina et al. 2016; Gómez-Moya et al. 2017; Polanco-Arjona et al. 2017). Although mid-southern Brazil is not very important in the produc-

tion of coconut, this plant is commonly found in southern Brazil and other parts of the country as backyard plantations, or as ornamentals in this and other Brazilian regions (IBGE 2017). Conversely, banana (*Musa* spp.; Musaceae), also a host of *R. indica* (Carrillo et al. 2011a), is an important crop in mid-southern Brazil, especially in the states of Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo. In fact, severe damage to banana varieties 'Prata' (AAB group) and 'Cavendish' (AAA group) was observed in 2016 in Missão Velha, Ceará State, northeastern Brazil (Rita de Cassia Rodrigues, personal communication). High levels of *R. indica* also were report-

Table 1. Sampling sites where *Raoiella indica* was present or absent¹ on each plant species in surveys conducted in mid-southern Brazil between Nov 2015 and Oct 2018.

| Host plant | Family | State | Municipality |
|--|---------------|---|---|
| PRESENT | | | |
| <i>Adonidia merrillii</i> (Becc.) | Arecaceae | Espírito Santo | Colatina and Marilândia |
| <i>Archontophoenix</i> sp. | Arecaceae | Paraná São Paulo | Umuarama Cerquillo |
| <i>Cocos nucifera</i> L. | Arecaceae | Espírito Santo Goiás Mato Grosso Mato Grosso do Sul Paraná Rio de Janeiro São Paulo | Colatina, Domingos Martins and Venda Nova do Imigrante Pirenópolis Sinop Bataguassu, Brasilândia, Santa Rita do Pardo and Três Lagoas Cafezal do Sul, Cianorte, Ibitiporã, Iguaraçu, Iporã, Jussara, Londrina, Maringá, Tamboara and Umuarama Rio de Janeiro Avaí, Castilho, Dracena, Itapura, Jaboticabal, Jafa, Lençóis Paulista, Marabá Paulista, Marília, Monte Aprazível, Nova Independência, Osvaldo Cruz, Pacaembu, Paulicéia, Piracicaba, Piratininga, Santópolis do Aguapeí, Vera Cruz and Ubatuba |
| <i>Euterpe edulis</i> Martius | Arecaceae | Paraná | Cruzeiro do Oeste |
| <i>Musa</i> sp. | Musaceae | São Paulo | Jafa and Piracicaba |
| <i>Phoenix roebelenii</i> O'Brien | Arecaceae | Distrito Federal Espírito Santo Mato Grosso Rio de Janeiro São Paulo | Brasília Linhares Sinop Petrópolis and Volta Redonda Jaguariúna |
| <i>Pritchardia hillebrandii</i> (Kuntze) Becc. | Arecaceae | São Paulo | Campinas |
| <i>Rhapis excelsa</i> (Thunb.) A. Henry | Arecaceae | Espírito Santo | Colatina |
| <i>Wodyetia bifurcata</i> AK Irvine | Arecaceae | Espírito Santo | Fundão and Nova Venécia |
| ABSENT ¹ | | | |
| <i>A. merrillii</i> | Arecaceae | Paraná | Palmeira and Ponta Grossa |
| <i>Archontophoenix</i> sp. | Arecaceae | Rio Grande do Sul | Boa Vista das Missões |
| <i>Butia eriospatha</i> (Mart. ex Drude) | Arecaceae | Rio Grande do Sul | Carazinho |
| <i>C. nucifera</i> | Arecaceae | Paraná | Campo Largo, Corbélia, Laranjeiras do Sul, Morretes, Palotina, Paranaguá, Ponta Grossa, Pontal do Paraná, Terra Roxa and Toledo |
| <i>E. edulis</i> | Arecaceae | Paraná | Cascavel and Irati |
| <i>Heliconia</i> sp. | Heliconiaceae | Paraná Paraná | Campo Largo Laranjeiras do Sul and Paranaguá |
| <i>P. roebelenii</i> | Arecaceae | Rio Grande do Sul Santa Catarina | Frederico Westphalen Campo Erê |
| <i>R. excelsa</i> | Arecaceae | Paraná | Cascavel, Laranjeiras do Sul, Morretes, Paranaguá and Ponta Grossa |
| <i>Roystonea oleracea</i> (Jacq.) | Arecaceae | Paraná | Cascavel and Guaraniçu |
| <i>Syagrus romanzoffiana</i> (Cham.) | Arecaceae | Paraná | Coronel Vivida, Curitiba, Guarapuava and Ivaiporã |

¹South of the southernmost site in which *R. indica* was found.

ed on banana cultivation in the Caribbean (Cocco & Hoy 2009; Kane et al. 2012; Rodrigues & Irish 2012).

The objective of this study was to evaluate the distribution of *R. indica* and associated predatory mites in mid-southern Brazil on coconut, banana, and a few other plant species on which this mite has been found, discussing the possible southern limit to its distribution in the country.

Materials and Methods

The study was conducted between 2015 and 2018, soon after the first detection of the mite in Brazil south of the Amazonas River (Oliveira et al. 2016). Symptomatic coconut plants (especially), as well as ornamental date and banana plants found along highways, urban parks, and nurseries were examined in the Federal District, and in the states of Espírito Santo (ES), Goiás (GO), Mato Grosso (MT), Mato Grosso do Sul (MS), Minas Gerais (MG), Paraná (PR), Rio de Janeiro (RJ), Rio Grande do Sul (RS), Santa Catarina (SC), and São Paulo (SP). When mites resembling *R. indica* were detected with the use of hand lenses, leaflets or leaf pieces were transferred to vials partially filled with 70% ethanol and transported to the laboratory, where the mites were collected and mounted in Hoyer's medium. They were subsequently identified to species by comparing their morphology with the information provided in the original descriptions and redescriptions in the literature. Representative specimens of the species collected were deposited in the mite reference collection of Departamento de Entomologia e Acarologia, Escola Superior de Agricultura "Luiz de Queiróz," Universidade de São Paulo (ESALQ/USP), Piracicaba, São Paulo, Brazil.

Results

Raoiella indica was found in the Federal District and 49 municipalities of the 9 states visited in the study (Table 1), of which the southernmost was Iporã, Paraná State (24.007222°S, 53.698333°W). It was not found in 26 other municipalities south of Iporã (Table 1, Fig. 1), namely: Paraná State: Campo Largo, Candoi, Cascavel, Corbélia, Coronel Vivida, Cruzeiro do Oeste, Curitiba, Guaraniaçú, Guarapuava, Imbaú, Irati, Ivaiporã, Laranjeiras do Sul, Mandaguari, Morretes, Palmeira, Palotina, Paranaguá, Ponta Grossa, Pontal do Paraná, Terra Roxa, and Toledo; Rio Grande do Sul State: Boa Vista das Missões, Carazinho, and Frederico Westphalen; Santa Catarina State: Campo Erê.

All 18 species of predatory mites found in association with *R. indica* are found in the order Mesostigmata (Table 2). Fourteen of them were in family Phytoseiidae, 1 in Blattisociidae, and 3 in Melicharidae. By far, the phytoseiid *Euseius citrifolius* Denmark & Muma was the most numerous and widespread (45 specimens found in 5 states), followed by *Iphiseiodes zuluagai* Denmark & Muma, and *Amblyseius largoensis* (Muma), also phytoseiids and both found in similar numbers (17 and 14 specimens in 3 and 1 states, respectively).

Discussion

The results of this study expand the known distribution of *R. indica* in Brazil to include areas where its most important host plant, coconut, is not an important crop. Although the absence of *R. indica* in some sampling sites could have been due to the unsuitability of some of the plants examined, this does not seem to have been the case, because in

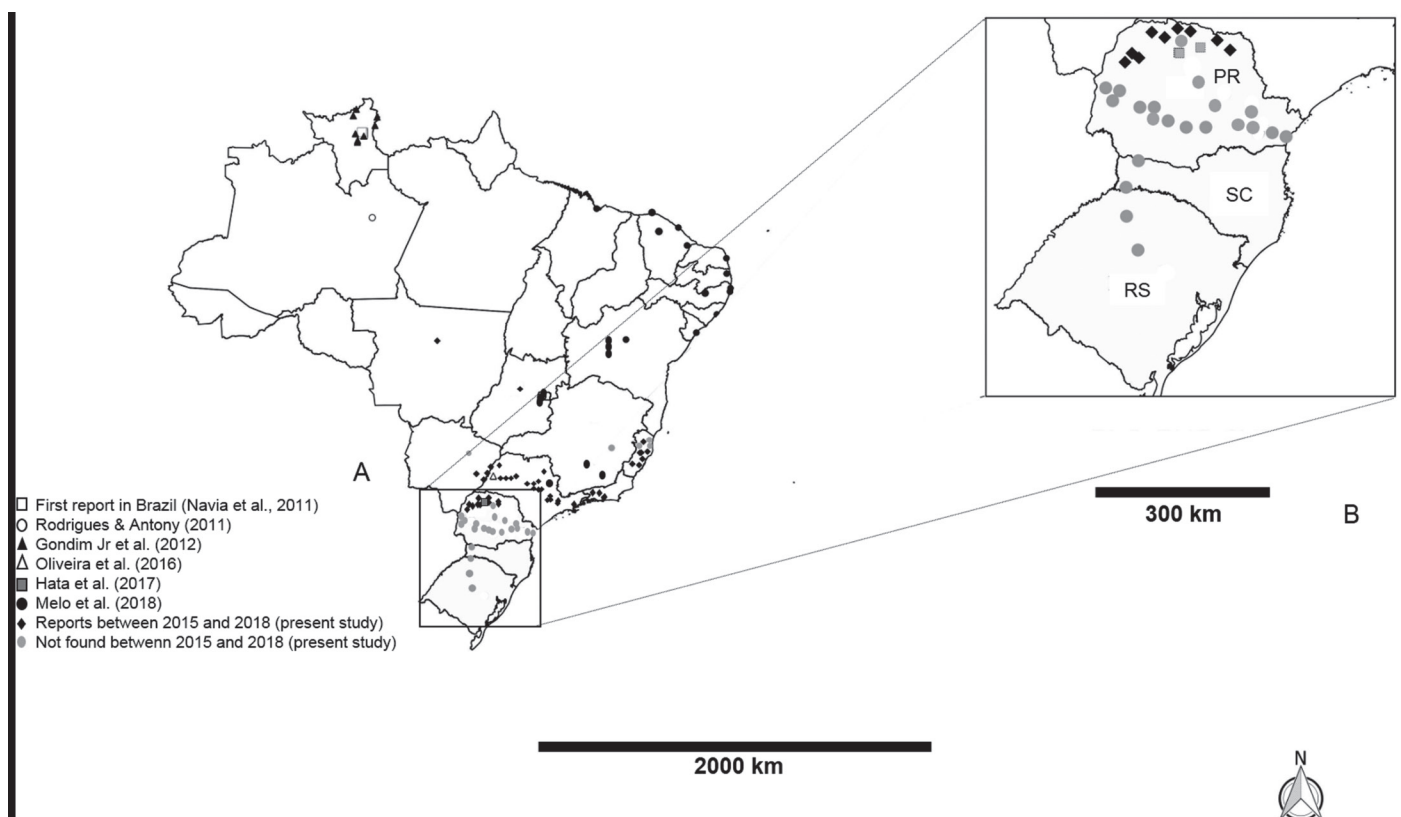


Fig. 1. New findings of *Raoiella indica* in mid-southern Brazil between 2015 and 2018, and previous records throughout the country. (A) Brazilian map showing sites where the presence of the mite has been evaluated in this and previous surveys; (B) Enlarged view of the position of sites in Paraná (PR), Rio Grande do Sul (RS), and Santa Catarina (SC) states.

most places the plants examined were known hosts of *R. indica*, except for *Syagrus romanzoffiana* (Cham.) Glassman (Aracaceae) (in Coronel Vivida, Curitiba, and Ivaiporã), where coconut was not found.

Although failure to find *R. indica* in some sampling areas could be by chance, its absence in areas of southern Brazil (Rio Grande do Sul, Santa Catarina, and part of Paraná States) could reflect the ecological unsuitability of those places. These results fit well with what was predicted by the model developed by Amaro & Morais (2013), based on 20 environmental variables. The authors concluded that the variables that most influenced their prediction were related to temperature. The altitude of the sites where *R. indica* was not found across the central region of Paraná State is at least about 500 masl, except Morretes, Palotina, Pontal do Paraná, and Terra Roxa (333, 374, 11, and 285 masl, respectively). Conversely, the altitude of the sites where it was found in the northern part of the state is at most 500 masl, except Londrina (543 masl). Hence, being higher and further south make central Paraná State colder than northern Paraná. An examination of the historical records (Continente 2018) showed that average minimum monthly temperatures in places where *R. indica* was found in northern Paraná are at least 9 °C, except Maringá (7.2 °C), whereas in places where it was not found, temperatures are at most 9 °C, except Morretes, Palotina, Pontal do Paraná, and Terra Roxa (12.3, 9.6, 13.7, and 9.8 °C, respectively). However, according to that the study of Amaro & Morais (2013), it is still possible that the mite could be found further south, along the coast of Rio Grande do Sul and Santa Catarina, areas not surveyed in this work. Also, according to that study, *R. indica* is expected to be able to extend south of the maximum latitude where it was detected dur-

ing the current study (Iporã), in neighboring Paraguay and Argentina, along the low lands of the Paraguay River basin.

The highest frequency of *R. indica* on coconut in this study is certainly due to the concentrated effort to search for it on symptomatic coconut, given its known preference for this host plant. The spread of *R. indica* is facilitated by the fact that new coconut plantations are usually established with plantlets acquired commercially, which may harbor the mite at low population levels, allowing its unnoticeable transportation over long distances. Dispersal can be facilitated further by the transportation of other infested plants that are used principally as ornamentals. The permanent availability of the host plant, and the seemingly limited capacity of natural enemies to maintain the pest at low levels, may account also for its ability to disperse (Navia et al. 2013). Hence, occurrence of *R. indica* south of Iporã in Brazil seems possible, in protected or restricted microhabitats, especially on protected ornamentals or in banana-producing areas, usually microhabitats with mild climate.

Although the diversity of predatory mites associated with *R. indica* in this study could not be considered low, not much can be said about the type of relationship they have to that prey, because basically most of those species found in this work have been reported from coconut in Brazil and elsewhere, regardless of the presence of *R. indica* (Lawson-Balagbo et al. 2008; Oliveira et al. 2012). *Amblyseius largoensis*, the third most numerous phytoseiid predator in association with *R. indica* in the present study, often has been reported in association with *R. indica* in the Neotropics, usually in coastal areas (Etienne & Flechtmann 2006; Rodrigues et al. 2007; Roda et al. 2008; Carrillo et al. 2010; Hastie et al. 2010; Carrillo et al. 2011c; Gondim Jr. et al. 2012; Moraes et al. 2012; Flores-Gallano et al. 2017). This

Table 2. Mesostigmatid mites associated with *Raoiella indica* on host plants in mid-southern Brazil in surveys conducted between 2015 and 2018.

| Taxa | Number of specimens | State | Host plant |
|---|---------------------|---|---|
| Phytoseiidae | | | |
| <i>Amblyseius acalyphus</i> Denmark & Muma | 5 | São Paulo | <i>Cocos nucifera</i> L. |
| <i>Amblyseius aeralis</i> (Muma, 1955) | 1 | Rio de Janeiro | <i>C. nucifera</i> |
| <i>Amblyseius chiapensis</i> De Leon | 6 | Espírito Santo and Paraná | <i>Archontophoenix</i> sp. |
| <i>Amblyseius compositus</i> Denmark & Muma | 2 | Paraná | <i>C. nucifera</i> |
| <i>Amblyseius herbicolus</i> (Chant) | 2 | Paraná | <i>C. nucifera</i> |
| <i>Amblyseius largoensis</i> (Muma) | 14 | Espírito Santo | <i>Adonidia merrillii</i> (Becc.) |
| <i>Amblyseius tamatavensis</i> Blommers | 8 | Espírito Santo and São Paulo | <i>C. nucifera</i> |
| <i>Amblyseius</i> sp. | 1 | Espírito Santo | <i>C. nucifera</i> |
| <i>Euseius alatus</i> De Leon | 2 | Paraná | <i>Archontophoenix</i> sp. |
| <i>Euseius citrifolius</i> Denmark & Muma | 45 | Goiás, Mato Grosso do Sul, Paraná, Rio de Janeiro and São Paulo | <i>Archontophoenix</i> sp., <i>C. nucifera</i> , <i>Euterpe edulis</i> Martius, <i>Musa</i> sp. and <i>Phoenix roebelenii</i> O'Brien |
| <i>Euseius concordis</i> (Chant) | 5 | Espírito Santo, Paraná and São Paulo | <i>A. merrillii</i> , <i>C. nucifera</i> and <i>E. edulis</i> |
| <i>Iphiseiodes zuluagai</i> Denmark & Muma | 17 | Mato Grosso do Sul, Rio de Janeiro and São Paulo | <i>C. nucifera</i> |
| <i>Neoseiulus anonymus</i> (Chant & Baker) | 1 | São Paulo | <i>C. nucifera</i> |
| <i>Proprioseiopsis ovatus</i> (Garman) | 2 | São Paulo | <i>C. nucifera</i> |
| <i>Typhlodromus (Anthoseius) transvaalensis</i> (Nesbitt) | 2 | São Paulo | <i>C. nucifera</i> |
| Immatures | 23 | | |
| Males | 3 | | |
| Blattisociidae | | | |
| <i>Blattisocius dentriticus</i> (Berlese, 1918) | 5 | São Paulo | <i>C. nucifera</i> |
| Melicharidae | | | |
| <i>Proctolaelaps bickleyi</i> (Bram) | 2 | Mato Grosso do Sul and São Paulo | <i>C. nucifera</i> |
| <i>Proctolaelaps pygmaeus</i> (J. Müller) | 1 | São Paulo | <i>C. nucifera</i> |
| <i>Proctolaelaps bulbosus</i> Moraes, Reis & Gondim Jr | 4 | São Paulo | <i>C. nucifera</i> |
| Immatures | 5 | | |
| Males | 5 | | |

predator has received the most attention as a possible candidate for practical use as biological control agent of the pest (Carrillo et al. 2010; Carrillo et al. 2011c; Carrillo et al. 2012; Domingos et al. 2012; Carrillo et al. 2014; Morais et al. 2016; Mendes et al. 2018).

In conclusion, since its first report in Brazil, *R. indica* now has been found in 18 states in the country, in sites ranging from 2°N to 23°S latitude. Complementary studies, especially in western Brazil, might demonstrate that it is also present there.

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References Cited

- Amaro G, Morais EGF. 2013. Potential geographical distribution of the red palm mite in South America. *Experimental and Applied Acarology* 60: 342–355.
- Carrillo D, Amalin D, Hosein F, Roda A, Duncan R, Peña JE. 2011a. Host plant range of *Raoiella indica* (Acari: Tenuipalpidae) in areas of invasion of the New World. *Experimental and Applied Acarology* 57: 271–289.
- Carrillo D, Coss ME, Hoy MA, Peña JE. 2012. Variability in response of four populations of *Amblyseius largoensis* (Acari: Phytoseiidae) to *Raoiella indica* (Acari: Tenuipalpidae) and *Tetranychus gloveri* (Acari: Tetranychidae) eggs and larvae. *Biological Control* 60: 39–45.
- Carrillo D, Frank JH, Rodrigues JCV, Peña JE. 2011c. A review of the natural enemies of the red palm mite, *Raoiella indica* (Acari: Tenuipalpidae). *Experimental and Applied Acarology* 57: 347–360.
- Carrillo D, Hoy MA, Peña JE. 2014. Effect of *Amblyseius largoensis* (Acari: Phytoseiidae) on *Raoiella indica* (Acari: Tenuipalpidae) by predator exclusion and predator release techniques. *Florida Entomologist* 97: 256–261.
- Carrillo D, Navia D, Ferragut F, Peña JE. 2011b. First report of *Raoiella indica* Hirst (Acari: Tenuipalpidae) in Colombia. *Florida Entomologist* 94: 370–371.
- Carrillo D, Peña JE, Hoy MA, Frank JW. 2010. Development and reproduction of *Amblyseius largoensis* (Acari: Phytoseiidae) feeding on pollen, *Raoiella indica* (Acari: Tenuipalpidae), and other microarthropods inhabiting coconuts in Florida, USA. *Experimental and Applied Acarology* 52: 119–129.
- Continentale SUM. 2018. Climate-data.org. <https://pt.climate-data.org/> (last accessed 30 Oct 2018).
- Cocco A, Hoy MA. 2009. Feeding, reproduction, and development of the red palm mite (Acari: Tenuipalpidae) on selected palms and banana cultivars in quarantine. *Florida Entomologist* 92: 276–291.
- Domingos CA, Oliveira LO, de Morais EGF, Navia D, de Moraes GJ, Gondim Jr MGC. 2012. Comparison of two populations of the pantropical predator *Amblyseius largoensis* (Acari: Phytoseiidae) for biological control of *Raoiella indica* (Acari: Tenuipalpidae). *Experimental and Applied Acarology* 60: 83–93.
- Etienne J, Flechtmann CHW. 2006. First record of *Raoiella indica* (Hirst, 1924) (Acari: Tenuipalpidae) in Guadeloupe and Saint Martin, West Indies. *International Journal of Acarology* 32: 331–332.
- Flechtmann CHW, Etienne J. 2004. The red palm mite, *Raoiella indica* Hirst, a threat to palms in the Americas (Acari: Prostigmata: Tenuipalpidae). *Systematic & Applied Acarology* 9: 109–110.
- Flores-Galano GF, Rodríguez-Morell H, Hernández-Turcas R, Miranda-Cabrera I, Montoya-Ramos A. 2017. Dinámica poblacional de *Raoiella indica* Hirst (Acari: Tenuipalpidae) en cocotero (*Cocos nucifera* L.) en Guantánamo, Cuba. *Revista Protección Vegetal* 32: 23–32.
- Gómez-Moya CA, Lima TPS, de Morais EGF, Gondim Jr MGC, de Moraes GJ. 2017. Hosts of *Raoiella indica* Hirst (Acari: Tenuipalpidae) native to the Brazilian Amazon. *Journal of Agricultural Science* 9: 86–94.
- Gondim Jr MGC, de Castro TMMG, Marsaro Jr AL, Navia D, Melo JW, Demite PD, de Moraes GJ. 2012. Can the red palm mites threaten the Amazon vegetation? *Systematics and Biodiversity* 10: 527–535.
- Hata FT, Silva JEP, Ventura MU, Pasini A, Roggia S. 2017. First report of *Raoiella indica* (Hirst) (Acari: Tenuipalpidae) in southern Brazil. *Neotropical Entomology* 46: 356–359.
- Hastie E, Benegas A, Rodríguez H. 2010. Inventario de ácaros depredadores asociados a fitoácaros en plantas de las familias Arecaceae y Musaceae. *Revista de Protección Vegetal* 25: 17–25.
- IGBE (Instituto Brasileiro de Geografia e Estatística). 2017. Levantamento sistemático da produção agrícola: pesquisa mensal de previsão e acompanhamento das safras no ano civil. Rio de Janeiro 30: 1-83. <<https://www.poder360.com.br/wp-content/uploads/2018/01/lspa-nov2017.pdf>> (last accessed 3 Feb 2019).
- Kane EC, Ochoa R, Mathurin G, Erbe EF, Beard JJ. 2012. *Raoiella indica* (Acari: Tenuipalpidae): an exploding mite pest in the Neotropics. *Experimental Applied Acarology* 57: 215–225.
- Lawson-Balagbo LM, Gondim Jr MGC, Moraes GJ de, Hanna R, Schausberger P. 2008. Exploration of the acarine fauna on coconut palm in Brazil with emphasis on *Aceria guerreronis* (Acari: Eriophyidae) and its natural enemies. *Bulletin of Entomological Research* 98: 83–96.
- Melo JWS, Navia D, Mendes JA, Filgueiras RMC, Teodoro AV, Ferreira JMS, Guzzo EC, de Souza IV, Mendonça RS, Calvet EC, Paz Neto AA, Gondim Jr MGC, de Morais EGF, Godoy MS, dos Santos JR, Silva RIR, da Silva VB, Norte RF, Oliva AB, dos Santos RBP, Domingos CA. 2018. The invasive red palm mite, *Raoiella indica* Hirst (Acari: Tenuipalpidae), in Brazil: range extension and arrival into the most threatened area, the Northeast Region. *International Journal of Acarology* 44: 146–149.
- Mendes JA, Lima DB, Sousa Neto EP, Gondim Jr MGC, Melo JWS. 2018. Functional response of *Amblyseius largoensis* to *Raoiella indica* eggs is mediated by previous feeding experience. *Systematic & Applied Acarology* 23: 1907–1914.
- Moraes GJ, de Castro TMMG, Kreiter S, Quilici S, Gondim Jr MGC, de Sá LAN. 2012. Search for natural enemies of *Raoiella indica* Hirst in La Réunion Island (Indian Ocean). *Acarologia* 52: 129–134.
- Morais EGF, Oliveira JS, Gondim Jr MGC, de Moraes GJ. 2016. *Amblyseius largoensis* in controlling red palm mite under semi-field conditions. *Pesquisa Agropecuária Brasileira*, Brasília 51: 671–675.
- Navia D, Marsaro Jr AL, Silva FR, Gondim Jr MGC, de Moraes GJ. 2011. First report of the red palm mite, *Raoiella indica* Hirst (Acari: Tenuipalpidae), in Brazil. *Neotropical Entomology* 40: 409–411.
- Navia D, Marsaro Jr AL, Gondim Jr MGC, Mendonça RS, Pereira PRVS. 2013. Recent mite invasions in South America, pp. 251–287 *In* Peña J [ed.], *Potential Invasive Pests of Agricultural Crops*. CAB International, Boston, Massachusetts, USA.
- Navia D, Morais EGF, Mendonça RS, Gondim Jr MGC. 2015. Ácaro vermelho-das-palmeiras, *Raoiella indica* Hirst, pp. 418–452 *In* Vilela EF, Zucchi RA [eds.], *Pragas Introduzidas no Brasil: Insetos e Ácaros*. ESALQ/USP, Piracicaba, São Paulo, Brazil.
- Oliveira DC, de Moraes GJ, Dias CTS. 2012. Status of *Aceria guerreronis* Keifer (Acari: Eriophyidae) as a pest of coconut in the state of São Paulo, southeastern Brazil. *Neotropical Entomology*, Londrina 41: 315–323.
- Oliveira DC, Prado EP, de Moraes GJ, de Moraes EGF, Chagas EA, Gondim Jr MGC, Navia D. 2016. First report of *Raoiella indica* (Acari: Tenuipalpidae) in southeastern Brazil. *Florida Entomologist* 99: 123–125.
- Otero-Colina G, González-Gómez R, Martínez-Bolaños L, Otero-Prevost LG, López-Buenfil JA, Escobedo-Graciamedrano RM. 2016. Infestation of *Raoiella indica* Hirst (Trombidiformes: Tenuipalpidae) on host plants of high socio-economic importance for tropical America. *Neotropical Entomology* 45: 300–309.
- Peña JE, Mannion CM, Howard FW, Hoy MA. 2006. *Raoiella indica* (Prostigmata: Tenuipalpidae): the red palm mite: a potential invasive pest of palms and bananas and other tropical crops in Florida. University of Florida IFAS Extension. Publication #ENY-837. University of Florida, Gainesville, Florida, USA. (online) <http://ufcd.ufl.edu/IR00002847/00001> (last accessed 3 Feb 2019).
- Polanco-Arjona CA, Osorio-Osorio R, Hernández-Hernández LU, Márquez-Quiroz C, Cruz-Lázaro E de la, Salinas-Hernández RM, Hernández-García V. 2017. Colonization, abundance, and damage of *Raoiella indica* Hirst on cultivars of *Musa* spp. at Tabasco, México. *Southwestern Entomologist* 42: 363–374.
- Roda A, Dowling A, Welbourn C, Peña JE, Rodrigues JCV, Hoy MA, Ochoa R, Duncan RA, De Chi W. 2008. Red palm mite situation in the Caribbean and Florida. *Proceedings of the Caribbean Food Crops Society* 44: 80–87.
- Rodrigues JCV, Antony LMK. 2011. First report of *Raoiella indica* (Acari: Tenuipalpidae) in Amazonas State, Brazil. *Florida Entomologist* 94: 1073–1074.
- Rodrigues JCV, Irish BM. 2012. Effect of coconut palm proximities and *Musa* spp. germplasm resistance to colonization by *Raoiella indica* (Acari: Tenuipalpidae). *Experimental and Applied Acarology* 57: 309–316.
- Rodrigues JCV, Ochoa R, Kane E. 2007. First report of *Raoiella indica* Hirst (Acari: Tenuipalpidae) and its damage to coconut palms in Puerto Rico and Culebra Islands. *International Journal of Acarology* 33: 3–5.
- Vásquez C, Quirós de GM, Aponte O, Sandoval DMF. 2008. First report of *Raoiella indica* Hirst (Acari: Tenuipalpidae) in South America. *Neotropical Entomology* 37: 739–740.
- Welbourn C. 2006. Pest Alert. Red palm mite *Raoiella indica* Hirst (Acari: Tenuipalpidae). http://www.freshfromflorida.com/content/download/66454/1601562/Pest_Alert_-_Raoiella_indica_Red_palm_mite.pdf (last accessed 3 Feb 2019).