Occurrence of *Raoiella indica* Hirst (Acari, Tenuipalpidae) in the Southeast region of the state of Pará, Brazil

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Abstract

The red palm mite *Raoiella indica* Hirst attacks coconut, banana and açai trees. In 2007, the mite was recorded for the first time in South America. In the State of Pará, *R. indica* was recorded in the municipalities of the northwest, a region that is closer to the State of Amazonas, called ‘Low Amazons’. Between October and November 2019, it was observed, by chance, that coconut and banana plants infested by *R. indica*, in residential backyards in municipalities from Marabá and Paraíapebas, Southeast of Pará, Brazilian Amazon. Three species from the Araceae family, two from Arecaceae, one Heliconiaceae and one Zingiberaceae, in addition to the banana Musaceae and açai plantations, were examined. All stages of development of *R. indica* were found on coconut, banana trees and imperial palms, and few individuals were found on areca palm and red ginger leaves. This is the first record of the occurrence of the pest mite in the Southeast Pará sub-region.

Keywords Red palm mite · Amazon · Banana trees · Coconut trees · Sub-region

Introduction

The red palm mite *Raoiella indica* Hirst, 1924 (Acari, Pros-tigmata, Tenuipalpidae), described in 1924 from specimens was collected from coconut trees (*Cocos nucifera* L., Arecaceae) na Índia (Hirst 1924). The mite attacks coconut and banana (*Musa* sp., Musaceae) leaves (Rodrigues et al. 2007; Morais et al. 2011; Gondin jr. et al. 2012; Kane et al. 2012). The mite was recently observed to cause severe injuries to açai palms (*Euterpe oleracea* Mart., Arecaceae) in Porto Seguro, in the state of Bahia (Nuvoloni et al. 2021). Other monocotyledonous plants of the families Heliconiaceae, Strelitziaceae, Zingiberaceae and Pandanaceae were considered reproductive hosts of *R. indica* (Carrillo et al. 2012). The mite causes yellowing and necrosis of leaves and even death of young plants (Etienne and Flechtmann 2006; Rodrigues et al. 2007).

*Raoiella indica* was first recorded in the Americas from specimens on the Caribbean island of Martinique (Flecht mann and Etienne 2004). Since then, economic losses have been recorded, mainly for coconut producers, in Caribbean countries (Rodrigues et al. 2007; Morais et al. 2011; Kane et al. 2012). In 2007, the mite was recorded for the first time in South America, in Venezuela (Vásquez et al. 2008) and later registered for the first time in Brazil in 2009, in the State of Roraima (Navia et al. 2011). In 2011, the mite was already in Manaus, in the state of Amazonas, still in the Brazilian Amazon region (Rodrigues and Antony 2011). In the following years, it was reported in several states of Brazil (Gómez-Moya et al. 2017; Hata et al. 2017; Oliveira et al. 2016; Barroso et al. 2019; Nora et al. 2019; Amaro et al. 2021; Castro et al. 2021). The mite was also been reported in Colombia (Carrillo et al. 2011) and more recently in...
Ecuador and Paraguay (Alcivar et al. 2020; Ramirez et al. 2020).

In the State of Pará, North Region of Brazil, _R. indica_ was recorded in the municipalities of the northwest, a sub-region that is closer to the State of Amazonas, called ‘Low Amazons’. The first record was in the municipality of Juruti, in 2016, by technicians from the ‘Agencia de Defesa Agropecuária do Pará’—ADEPARA (Adepara 2016). Subsequently, surveys carried out in 12 of the 15 municipalities of the low amazons revealed the presence of _R. indica_ in 11 of these, Alenquer, Almeirim, Belterra, Curuá, Faro, Mojuí dos Campos, Monte Alegre, Óbidos, Prainha, Santarém and Terra Santa (Moraes et al. 2017; Noronha et al. 2018).

Pará is the second largest state from Brazil (1,248 mi²), more than twice the territory of France and five times that of São Paulo, the most important Brazilian scientific and economic center. The state is the leader in the national production of açai, and the 3rd and 4th largest producer of bananas and coconuts, respectively (Ibge 2022). Not all production of açai, and the 3rd and 4th largest producer of bananas and coconuts, respectively (Ibge 2022). Not all regions of the state are interconnected. The relative isolation of the sub-regions would make it possible to plan effective phytosanitary barriers, by ADEPARA, seeking to hinder the dispersion of _R. indica_ to the municipalities that produce açai, banana and coconut. In this context, we aimed to confirm the presence of the red palm mite in the sub-region of Southeast Pará, hitherto free of the mite.

### Results

_Raoiella indica_ had been reported only in the Low Amazons municipalities (Fig. 2). In the municipalities prospected in the Northeast of Pará, until 2018, the mite was not detected (Fig. 2). In the following year (2019), however, the mite was found in Southeast Pará, in municipalities distant about 1,000 km from the places where it occurs in the State (Fig. 2).

Abundance of _R. indica_, with the presence of all stages of development, was only observed in coconut, banana and imperial palm. At the time, these mites were not observed in açai plants (nor in more recent surveys). A few individuals, all adults, were observed on areca palm (Dypsis lutescens (H.Wendl.) Beentje & J.Dransf.) leaves, in Marabá, and on red ginger leaves, in Paraúapebas (Table 1).

### Discussion

In the state of Pará, there are three Köppen climate types: Af—equatorial tropical, Am—monsoon tropical and Aw—savanna tropical (Alvares et al. 2013). The Aw climate occurs only in the Southeast of Pará sub-region, comprising a defined dry period in addition to high Amazonian temperatures (Alvares et al. 2013). Phytophagous mites are generally favored by periods of low rainfall and relative humidity (Cruz et al. 2013). _Raoiella indica_ completed its development only in between 20 and 30 °C of air temperature and the reproductive parameters were higher at 27 °C, this being its optimal temperature (Fidelis et al. 2019). The climate in Marabá and Paraúapebas is Aw (Köppen and Geiger, 1928), with average temperatures above 26 °C and annual precipitation around 1,800 mm (Inmet 2022). Thus, an estimate based on computer models showed probabilities of 0.4 and 0.6 (scale from 0 to 1) of _R. indica_ occurring in the municipalities of Marabá and Paraúapebas (Amaro et al. 2021). This work corroborates this estimate.

The municipalities of Southeast Pará are much closer to the states of Maranhão and Tocantins than to the Low Amazons (Fig. 1); in addition, there are more interstate trade...
routes from Southeast Pará than between the sub-regions of the state. This allows us to conjecture that it is likely that the population of *R. indica* found in this study came from these other states, from populations already identified in Northeast Brazil. There is still no record of the mite in Maranhão and Tocantins (Amaro et al. 2021).

This work is the first record of the mite in areca palm. This mite, in their dispersal, they could land in any plant species, but it does not mean this plant is a reproductive host for the mite. It is necessary to analyze whether the mite is capable of developing and reproducing on the plant (Carrillo et al. 2012).

Since the mite was found in Southeast Pará, and considering the theoretically favorable climatic conditions for *R. indica* in this region, it is now essential to conduct more in-depth studies, in the region and nearby states, about the dynamics of these mite populations and the occurrence or not of effective natural enemies for later sustainable pest management strategies.

Fig. 1 The mite *Raoiella indica* on an imperial palm leaflet. A Mite colony with all stages of development (egg, nymphs, male and female adults); B detail of a female; C female and D male *R. indica* under a microscope.
Fig. 2  Map of the State of Pará, highlighting the municipalities where the red palm mite was found (in red) in the Low Amazons (Moraes et al. 2017; Noronha et al. 2018); municipalities where the mite was prospected and not found (in green), most in the 'Northeast of Pará' (Noronha et al. 2018); municipalities of Marabá and Parauapebas (in yellow) in the Southeast of Pará

Table 1  Hosts investigated in the municipalities of Marabá and Parauapebas, between October and November 2019 to July 2022, in the region of Carajás, in the southeast of the State of Pará

| Common name       | Family       | Scientific name                                      | Locality* | Year | Presence of R. indica** |
|-------------------|--------------|------------------------------------------------------|-----------|------|-------------------------|
| Damp Cane         | Araceae      | Dieffenbachia seguine (Jacq.) Schott                | P         | 2019 | –                       |
| Flamingo Flower   |              | Anthurium andraeanum Linden ex André                | M         | 2019 | –                       |
| Pacova            |              | Philodendron martianum Engl                         | M         | 2019 | –                       |
| Coconut tree      | Areaceae     | Cocos nucifera L                                    | M and P   | 2019 | ++ ++                   |
| Areca palm        |              | Dypsis lutescens (H.Wendl.) Beentje & J.Dransf      | M         | 2019 | +                       |
| Açai plantations  |              | Euterpe oleracea Mart                               | M and P   | 2019/2022 | –                   |
| Imperial palm     |              | Roystonea oleracea (Jacq.)                         | P         | 2022 | ++                      |
| Heliconia         | Heliconiaceae| Heliconia sp.                                        | M         | 2019 | –                       |
| Banana tree       | Musaceae     | Musa x paradisiaca L                                | M and P   | 2019 | ++ ++                   |
| Torch ginger      | Zingiberaceae| Etlingera elatior (Jack.) R.M. Smith                | P         | 2019 | –                       |
| Red ginger        |              | Alpinia purpurata (Vieill.) K. Schum                | P         | 2022 | +                       |

*M = Marabá;  P = Parauapebas.  **++ ++ = Great abundance of Raoiella indica found; ++ = Intermediate abundance of R. indica found; + = few individuals of R. indica found; – = Raoiella indica not found.
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Declarations

Competing interests The authors did not receive support from any organization for the submitted work. The authors declare they have no financial or non-financial interests.

References

Agência de Defesa Agropecuária do Pará (2016) Confirmada presença de ácaro vermelho em Juruti. [Belém, PA], 2016. http://www.defesaagropecuaria.net/single-post/2016/04/11/ADEPAR%C3% 81-Confirmada-a-presen%C3%A7a-de-%C3%A1caro-vermelho-emjuruti. Accessed 13 April 2021

Alcivar J, Mesa NC, Vásquez C (2020) First report of Raoiella indica Hirst (Acari: Tenuipalpidae) in province of Manabi, Ecuador. Int J Acarol 46:120–122. https://doi.org/10.1080/01674954.2020. 1719195

Alvesres CA, Stape JL, Sentelhas PC, Goncalves JLM, Sparovek G (2013) Köppen’s climate classification map for Brazil. Meteo Zeitschrift 22:711–728. https://doi.org/10.1127/0941-2948/2013/ 0507

Amaro G, Fidelis EG, da Silva RS, de Medeiros CM (2021) Current and potential geographic distribution of red palm mite (Raoiella indica Hirst) in Brazil. Ecol Inform 65:101396. https://doi.org/10. 1016/j.ecoinf.2021.101396

Barroso G, da Rocha CM, Moreira GF, Hata FT, Roggia S, Ventura MU, Pasini A, da Silva JEP, Holtz AM, de Moraes GJ (2019) What is the southern limit of the distribution of red palm mite, Raoiella indica (Acari: Tenuipalpidae), in agricultural lands in Brazil? Fla Entomol 102:581–585. https://doi.org/10.1653/024. 0507

Beard JJ, Ochoa R, Mathurin G, Erbe EF, Beard JJ (2012) Raoiella indica (Acari: Tenuipalpidae): an exploding mite pest in the neotropics. Exp Appl Acarol 57:215–225. https://doi.org/10.1007/s10493-012-9541-1

Köppen W, Geiger R (1928) Klimate der Erde. Gotha: Verlagshandlungen. Justus Perthes. n.p

Moraes RF, Pereira CAB, Corrêa CLPS, Noronha ACS (2017) Ácaro-vermelho-das-palmeiras no Estado do Pará. Belém/PA: Anais do 21 Seminário de Iniciação Científica da Embrapa Amazônia Oriental

Moraes GF, Navia D, Gondim Junior MGC (2011) Host and potential geographic distribution of red palm mite Raoiella indica Hirst (Tenuipalpidae): Uma ameaça para palmeiras e bananeiras no Brasil. Boa Vista/RR: Embrapa Roraima (Documentos n.49). 17 p

Navia D, Marsaro Junior AL, Silva FR, Gondim Junior MGC, de Moraes GJ (2011) First report of the red palm mite, Raoiella indica Hirst (Acari: Tenuipalpidae), in Brazil. Neotrop Entomol 43:356–359. https://doi.org/10.1007/ s13744-016-0468-9

Hirsh S (1924) On some new species of red spider. Ann Mag Nat Hist 14:522–527. https://doi.org/10.1080/00222932408633151

Instituto Brasileiro de Geografia E Estatística – IBGE. (2022) PAM – Produção Agrícola Municipal: Tabela 2022. https://www.ibge. gov.br/estatisticas/economicas/agricultura-e-pecauraria/9117-produ cao-agricola-municipal-culturas-temporarias-e-permanentes.html. Accessed 20 Jun 2022

Instituto Nacional de Meteorologia – INMET. (2022) Normais climatológicas do Brasil. https://portal.inmet.gov.br/normais. Accessed 27 April 2022

Kane EC, Ochoa R, Mathurin G, Erbe EF, Beard JJ (2012) Raoiella indica (Acari: Tenuipalpidae): an exploding mite pest in the neotropics. Exp Appl Acarol 57:215–225. https://doi.org/10.1007/s10493-012-9541-1

What is the southern limit of the distribution of red palm mite, Raoiella indica (Hirst, 1924) (Acari: Tenuipalpidae) in Guadeloupe and Saint Martin, West Indies. Int J Acarol 32:331–332

Fidelis EG, Reis MAS, Negrini M, Navia D (2019) Life table parameters of the red palm mite Raoiella indica (Acari: Tenuipalpidae) at various temperatures and for sexual and asexual reproduction. Exp Appl Acarol 78:535–546. https://doi.org/10.1007/s10493-019-00407-y

Flechtmann CHW, Etienne J (2004) The red palm mite, Raoiella indica Hirst, a threat to palms in the Americas (Acari: Prostigmata: Tenuipalpidae). Syst Appl Acarol 9:109–110. https://doi.org/10. 11158/saa.9.1.16

Gómez-Moya CA, Lima TPS, Morais EGFD, Gondim Junior MGC, Moraes GJ (2017) Hosts of Raoiella indica Hirst (Acari: Tenuipalpidae) native to the Brazilian Amazon. J Agric Sci 9:86–94. https://doi.org/10.5539/jas.v9n4p86

Gondim Junior MGC, Castro TMMG, Marsaro Junior AL, Navia D, Melo JWS, Demite PR, de Moraes GJ (2012) Can the red palm mite threaten the Amazon vegetation? Syst Biodivers 10:527–535. https://doi.org/10.1080/14772000.2012.752415

Hata FT, Silva JEP, Ventura MU, Roggia S (2017) First report of Raoiella indica (Hirst) (Acari: Tenuipalpidae) in Southern Brazil. Neotrop Entomol 43:356–359. https://doi.org/10.1007/ s13744-016-0468-9

Hirsh S (1924) On some new species of red spider. Ann Mag Nat Hist 14:522–527. https://doi.org/10.1080/00222932408633151

Instituto Brasileiro de Geografia E Estatística – IBGE. (2022) PAM – Produção Agrícola Municipal: Tabela 2022. https://www.ibge. gov.br/estatisticas/economicas/agricultura-e-pecauraria/9117-produ cao-agricola-municipal-culturas-temporarias-e-permanentes.html. Accessed 20 Jun 2022

Instituto Nacional de Meteorologia – INMET. (2022) Normais climatológicas do Brasil. https://portal.inmet.gov.br/normais. Accessed 27 April 2022

Kane EC, Ochoa R, Mathurin G, Erbe EF, Beard JJ (2012) Raoiella indica (Acari: Tenuipalpidae): an exploding mite pest in the neotropics. Exp Appl Acarol 57:215–225. https://doi.org/10.1007/s10493-012-9541-1
(Arecaceae) in the State of Bahia, Brazil. Syst Appl Acarol 26:1769–1775. https://doi.org/10.11158/saa.26.9.10
Oliveira DC, Prado EP, Moraes GJ, Morais EGF, Chagas EA, Gondim Junior MGC, Navia D (2016) First report of Raoiella indica (Acari: Tenuipalpidae) in southeastern Brazil. Fla Entomol 99:123–125. https://doi.org/10.1653/024.099.0124
Ramírez MB, Sarubbi HJ, Arias O, Azevedo LH, Flechtmann CHW (2020) First report of Raoiella indica Hirst (Acari: Tenuipalpidae) in Paraguay. J Plant Dis Prot 127:715–717. https://doi.org/10.1007/s41348-020-00312-2
Rodrigues JCV, Antony LMK (2011) First report of Raoiella indica (Acari: Tenuipalpidae) in Amazonas state, Brazil. Fla Entomol 94:1073–1074. https://doi.org/10.1653/024.094.0452
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. Int J Acarol 33:3–5. https://doi.org/10.1080/01647950708684493
Vásquez C, De GMQ, Aponte O, Sandoval MF (2008) First Report of Raoiella indica Hirst (Acari: Tenuipalpidae) in South America. Neotrop Entomol 37:739–740. https://doi.org/10.1590/S1519-566X2008000600019

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