Hosts of *Raoiella indica* Hirst (Acari: Tenuipalpidae) Native to the Brazilian Amazon

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Abstract

The expansion of red palm mite (RPM), *Raoiella indica* (Acari: Tenuipalpidae) in Brazil could impact negatively the native plant species, especially of the family Arecaceae. To determine which species could be at risk, we investigated the development and reproductive potential of *R. indica* on 19 plant species including 13 native species to the Brazilian Amazon (12 Arecaceae and one Heliconiaceae), and six exotic species, four Arecaceae, a Musaceae and a Zingiberaceae. Values of the instantaneous rate of increase (r_i) were initially estimated at 7, 14, 21 and 28 days after infestation of each species. Higher values of r_i (> 0.05) were determined on the Arecaceae *Adonidia merrillii*, *Astrocaryum jauari*, *Cocos nucifera*, *Bactris simplicifrons*, *Mauritia flexuosa*, *Phoenix dactylifera* and *Socratea exorrhiza*, and on the Heliconiaceae *Heliconia psittacorum* Sassy; these were classified as "potential primary hosts". Lower, but still positive values of r_i (0-0.05) were determined on the Arecaceae *Bactris maraja*, *Oenocarpus bacaba*, *Oenocarpus bataua* and on the Musaceae *Musa × paradisiaca* (Prata variety); these were classified as "potential secondary hosts". Negative values of r_i were determined for the remaining plants, *i.e.*, the Arecaceae *Astrocaryum aculeatum*, *Attalea maripa*, *Bactris gasipaes*, *Elaeis guineensis*, *Euterpe oleracea*, *Euterpe precatoria*, and the Zingiberaceae *Alpinia rosea*; these were considered "non-hosts". Species with r_i < 0.05 were considered not to be threatened by the RPM. Biological parameters of RPM were evaluated on the plant species with positive r_i (except *B. maraja*) and two native species with negative r_i (*E. oleracea* and *E. precatoria*). Mean developmental time ranged from 14.7 days on *C. nucifera* to 21.4 days on *Musa × paradisiaca*, showing a significant influence of the plant substrate. Immature viability, oviposition rate, net reproductive rate (R_0) and intrinsic rate of increase (r_m) were affected by the plant species.

Keywords: Arecaceae, invasive species, red palm mite, instantaneous rate of increase

1. Introduction

The red palm mite (RPM), *Raoiella indica* Hirst (Acari: Tenuipalpidae), was described from specimens collected in India on *Cocos nucifera* L. (Hirst, 1924). This species had only been reported from the Eastern Hemisphere (Dowling, Ochoa, Beard, Welrn, & Ueckermann, 2012) before its detection in the Caribbean area by Flechtmann and Etienne (2004). RPM is currently distributed throughout the Caribbean area (Kane, Ochoa, Mathurin, Erbe, & Beard, 2012), also reaching Mexico (North American Plant Protection Organization [NAPPO], 2009), Florida (Peña, Bruin, & Sabelis, 2012), Venezuela (Vásquez, Quirós, Aponte, & Sandoval, 2008), Colombia (Carrillo, Navia, Ferragut, & Peña, 2011) and Brazil (Navia, Marsaro Jr., Silva, Gondim Jr., & Moraes, 2011). In Brazil, RPM was first reported in the northern states of Roraima (Navia et al., 2011) and Amazonas (Rodrigues & Antony, 2011); it was very recently reported in the northeastern states of Alagoas, Ceará and Sergipe, and in the

southern states of Mato Grosso and São Paulo (Empresa Brasileira de Pesquisa Agropequária [EMBRAPA], 2015; Oliveira et al., 2016).

In the Eastern Hemisphere, *R. indica* has been reported on plants of only four genera of Arecaceae: *C. nucifera*, *Phoenix dactylifera* L., *Dictyosperma album* (Borg.), *Areca* sp. and *Areca catechu* L. (Navia, Morais, Mendoça, & Gondim Jr., 2015). However, in the Western Hemisphere it greatly expanded its host range, being now known from 95 plant species belonging to 58 genera of eight families: Arecaceae, Cannaceae, Cycadaceae, Heliconiaceae, Musaceae, Pandanaceae, Strelitziaceae and Zingiberaceae (Carrillo et al., 2012; Vásquez & Moraes, 2012). About 81% of the known host species belong to Arecaceae; all others belong to other monocotyledonous families (Carrillo et al., 2012). Reports of dicotyledonous plants (Apocynaceae, Fabaceae and Sterculiaceae) as hosts probably refer to mites found while in the process of dispersion to the actual hosts (Vásquez, Colmenárez, & Moraes, 2015). About 65% of the hosts reported in the Americas are species introduced from the Eastern Hemisphere; about a quarter of the reported hosts are plants native to the New World, especially South America (Carrillo et al., 2012). The following species native to the Brazilian Amazonia have been reported as hosts: the Heliconiaceae *Heliconia bihai* (L.) and *Heliconia psittacorum* Sassy, and the Arecaceae *Attalea maripa* (Aubl.) Mart., *Bactris gasipaes* Kunth, *Euterpe oleracea* Mart., *Euterpe precatoria* Mart. and *Mauritia flexuosa* L. (Gondim et al., 2012).

The objectives of this study were to determine whether selected plants of families Arecaceae, Heliconiaceae, Musaceae and Zingiberaceae commonly found in the Brazilian Amazon could serve as hosts for *R. indica*, including some species previously reported as hosts (*H. psittacorum* and the Arecaceae *A. maripa*, *B. gasipaes*, *E. oleracea*, *E. precatoria* and *M. flexuosa*), to confirm previous results indicating those plants as potential hosts, given the very common occurrence of these plants in northern Amazon.

2. Method

Plants evaluated in this study included 13 species native to the Brazilian Amazon, of which twelve Arecaceae (*Astrocaryum aculeatum* G. Mey., *Astrocaryum jauari* Mart., *A. maripa*, *B. gasipaes*, *Bactris maraja* Mart., *Bactris simplicifrons* Mart., *E. oleracea*, *E. precatoria*, *M. flexuosa*, *Oenocarpus bacaba* Mart., *Oenocarpus bataua* Mart. and *Socratea exorrhiza* (Mart.) H. Wendl.) and one Heliconiaceae (*Heliconia psittacorum* L.f); and six exotic species, of which four Arecaceae (*Adonidia merrillii* (Becc.) Becc., *C. nucifera, Elaeis guineensis* Jacq., and *P. dactylifera*), one Musaceae (*Musa × paradisiaca* L., Prata variety) and one Zingiberaceae (*Alpinia rosea* Elmer). The following species were introduced as control, for being already known as true hosts: *A. merrillii*, *C. nucifera*, *P. dactylifera* and *Musa × paradisiaca*. Seedlings of these plant species were obtained from Embrapa Roraima and commercial nurseries and natural areas of Roraima State, Brazil [Cantá (02º36′36″N 60º35′49″W, 02º48′55.09″N 60º39′05.7″W), Boa Vista (02º45′29.2″N 60º43′54.7″W) and São João de Baliza (00º57′03″N 59º54′39″W)]. The seedlings were planted in 20 L polyethylene pots filled with a mixture of soil and cattle manure and irrigated manually once a day. Plants were about 0.2-1.1 m high and had 3-4 leaves.

2.1 RPM Stock Colony

Specimens of RPM were obtained from *C. nucifera* plants in Boa Vista (02º45′29.2″N 60º43′54.7″W). Adults were transferred to leaflets of *A. merrillii* placed (upside down) onto a piece of foam map moisten daily with distilled water. Mites were weekly transferred to new leaflets. The stock colony was maintained in Entomology Laboratory of Embrapa Roraima at uncontrolled environmental conditions (ca. 26 ºC, 60% RH and natural photophase (ca. 12:12 h L: D). Twenty-one day before of the study, 100 adult females were transferred to a new *A. merrillii* leaflet and removed 24 h later, leaving only the eggs they laid. This new generation was reared to adulthood to be used in the determination of the instantaneous rate of increase (r_i).

2.2 Instantaneous Rate of Increase

The experiment was conducted in a screenhouse at Embrapa Roraima. It was conducted under a randomized block design, with five blocks and 19 plant species as treatments, each experimental unit corresponding to a plant. Three recently molted adult females of *R. indica* were transferred to a rectangle of 1.5 × 3.0 cm delineated with entomological glue onto the lower surface of a randomly selected leaf or leaflet (according to plant species) of each third (basal, median and apical) of each seedling. The number of mites in each developmental stage in each rectangle was counted 7, 14, 21 and 28 days later. The instantaneous rate of increase (r_i) of *R. indica* on each plant species was estimated using the following equation proposed by Hall (1964):

$$r_i = \ln (n_f/n_o)/\Delta_t \tag{1}$$

Where, n_f is the final number of mites, n_o is the initial number of mites, and Δ_t is the elapsed time. Mean values were calculated as follows:

$$r_i = (r_{i7} + r_{i14} + r_{i21} + r_{i28})/4 \qquad (2)$$

Where, r_{i7}, r_{i14}, r_{i21} and r_{i28} are respectively the instantaneous rate of increase for each species 7, 14, 21 and 28 days after mite confinement. Using a modification of the criterium proposed by Stark, Tanigoshi, Bounfour and Antonelli (1997) and Walthall and Stark (1997), the suitability of plant species as host estimated by the determined values of r_i. The plant was classified as "primary or potential primary host" if $r_i > 0.05$, as "potential secondary host" if $r_i = 0.05$-0.00, and as "non-host" if $r_i < 0.00$.

2.3 Biological Parameters

Developmental time, oviposition and daily survivorship rates of *R. indica* were determined on the following plant species on which r_i was positive: *A. jauari, A. merrillii, B. simplicifrons, C. nucifera, H. psittacorum, M. flexuosa, Musa × paradisiaca* (Prata variety), *O. bacaba, O. bataua, P. dactylifera* and *S. exorrhiza* and on two native species on which r_i was negative (*E. precatoria* and *E. oleracea*); the latter two plants were included because of their economic and ecological importance in the Amazon region. A completely randomized design was adopted, using five seedlings of *A. merrillii, E. precatoria, E. oleraceae, M. flexuosa, O. bacaba, O. bataua, P. dactylifera* and *Musa × paradisiaca* and 8-10 seedlings of *A. jauari, B. simplicifrons, C. nucifera, S. exorrhiza* and *H. psittacorum* (numbers varying according to the architecture/structure of each plant).

The study was initiated with recently laid eggs. For such, three *R. indica* adult females were transferred from the stock colony to rectangles (2.0 × 3.0 cm) delimited with entomological glue on the undersurface of undetached leaflets (one on each of seven leaflets of composite leaves) or leaves (seven rectangles on a single non-composite leaf) at taken from the median stratum of the plant canopy. Twenty-four hours later, the females and part of the eggs laid were removed, leaving one to five eggs per rectangle. The units were examined once a day for counting the number of mites in each stage. Newly emerged females were transferred to new similar experimental units, adding an adult male taken from the stock colony to each unit. Dead males were replaced by new ones until the female died. Sex ratio was estimated based on offspring obtained in the first 10 days of oviposition (Schulten, 1985).

All evaluations for the determination of r_i and for the study of the biology of *R. indica* were carried out using 30× or 60× hand lens (LED HG498). The environmental conditions were recorded every 10 minutes using a Hobo Data Loggers[®].

2.4 Statistical Analysis

Values of r_i, viability of immature forms, developmental time, oviposition period, sex ratio, longevity and daily oviposition rates were subjected to an analysis of variance (PROC GML), using the statistical package SAS version 9.0 (SAS Institute, 2003, 2008), after testing the data for normality and homoscedasticity (Kolmogorov and Bartlett tests, respectively). Data that could not be normalized were subjected to Kruskal-Wallis non-parametric test (Proc NPAR1WAY), SAS version 9.0 (SAS Institute, 2003, 2008). Fertility life table parameters [net reproductive rate (*Ro*), generation time (*T*), and intrinsic rate of increase (*r*$_m$)] were estimated using the Jackknife procedure, as described by Maia, Luiz and Campanhola (2000), using SAS/Enterprise Guide 4.3 (SAS Institute, 2003, 2008). Pearson correlation between r_i and r_m was performed (SAS/Enterprise Guide 4.3, SAS Institute, 2003, 2008).

3. Results

3.1 The Instantaneous Rate of Increase

Significant differences in r_i values were observed seven days ($\chi^2 = 197.18$; $df_{18, 250}$; $P < 0.0001$), 14 days ($\chi^2 = 130.71$; $df_{17, 170}$; $P < 0.0001$), 21 days ($\chi^2 = 60.47$; $df_{13, 117}$; $P < 0.0001$) and 28 days ($\chi^2 = 62.37$; $df_{9, 104}$; $P < 0.0001$)] after mite confinement (Table 1). Values higher than 0.05 were observed on *A. jauari, A. merrillii, B. simplicifrons, C. nucifera, M. flexuosa, P. dactylifera, S. exorrhiza* and *H. psittacorum*; almost invariably, these values reduced along the experiment. Values between 0.05 and 0.00 were observed on *B. maraja, O. bacaba, O. bataua* and *Musa × paradisiaca*. Negative values were observed on *A. aculeatum, A. maripa, A. rosea, B. gasipaes, E. guineensis, E. oleraceae* and *E. precatoria*.

Table 1. Estimation of instantaneous rate of increase (r_i; Mean ± SE) of *Raoiella indica* on different hosts. Boa Vista, Roraima State, Brazil. T = 29±4,03 ºC, RH = 78±13,32%, natural light: darkness (ca. 12:12 h)

Species	Family	Days from infestation date					
		7	14	21	28	Overall Mean	Status[a]
EXOTICS							
Adonidia merrillii	Arecaceae	0.34±0.01 a[a]	0.18±0.01 a	0.11±0.01 a	0.11±0.01 a	0.19±0.01	Host
Cocos nucifera	"	0.26±0.01 b	0.16±0.01 ab	0.11±0.01 ab	0.08±0.01 b	0.15±0.01	Host
Elaeis guineensis	"	-0.01±0.01 ef	Extinct			-0.01±0.02	Non-host
Phoenix dactylifera	"	0.16±0.02 c	0.08±0.02 ef	0.04±0.01 def	0.04±0.01 c	0.08±0.01	Host
Alpinia rosea	Zingiberaceae	0.01±0.02 e	-0.03±0.01 g	-0.05 f	Extinct	-0.02±0.01	Non-host
Musa × paradisiaca	Musaceae	-0.01±0.04 ef	0.02±0.04 fg	0.03±0.08 cdfe	0.06 abcdb	0.02±0.03	Secondary host
NATIVES							
Astrocaryum aculeatum	Arecaceae	0.00±0.02 e	-0.05±0.01 g	Extinct		-0.02±0.01	Non-host
Astrocaryum jauari	"	0.23±0.01 b	0.12±0.01 cd	0.06±0.01 d	0.03±0.01 c	0.11±0.01	Host
Attalea maripa	"	-0.06±0.02 ef	-0.06±0.01 g	-0.05±0.01 f	Extinct	-0.05±0.02	Non-host
Bactris gasipaes	"	-0.04±0.02 ef	-0.04±0.02 g	Extinct		-0.04±0.0	Non-host
Bactris maraja	"	0.07±0.02 d	0.00±0.01 g	0.00 def	Extinct	0.02±0.01	Secondary host
Bactris simplicifrons	"	0.22±0.01 b	0.13±0.01 bc	0.09±0.01	0.07±0.01 b	0.13±0.01	Host
Euterpe precatoria	"	-0.06±0.02 ef	-0.05±0.03 g	Extinct		-0.06±0.02	Non-host
Euterpe oleracea	"	0.02±0.02 de	-0.04±0.02 g	Extinct		-0.01±0.01	Non-host
Mauritia flexuosa	"	0.25±0.01 b	0.13±0.01 c	0.06±0.01	0.02±0.01 cd	0.12±0.01	Host
Oenocarpus bacaba	"	0.06±0.03 de	0.04±0.02 ef	0.06±0.01	0.05±0.01 c	0.05±0.01	Secondary Host
Oenocarpus bataua	"	0.00±0.04 e	0.00±0.04 g	0.06±0.02	Extinct	0.02±0.02	Secondary Host
Socratea exorrhiza	"	0.21±0.02 bc	0.09±0.02 de	0.04±0.01	0.02±0.01 cd	0.09±0.01	Host
Heliconia psittacorum	Heliconiaceae	0.16±0.02 c	0.09±0.01ef	0.03±0.01	0.01±0.01 d	0.07±0.01	Host

Note. [a]Potential primary hosts (= hosts): overall $r_i > 0.05$; Potential secondary host: $0.0 \leq$ overall $r_i \leq 0.05$; Non-hosts: $ri < 0$. Within a column, means followed by the same letter are not significantly different (Kruskal-Wallis test: p > 0.05).

3.2 Biological Parameters

RPM completed development on all evaluated plant species (Table 2). However, the few females reaching adulthood on *E. oleracea* and *E. precatoria* did not oviposit. Mean developmental time ranged from 14.7 days on *C. nucifera* to 21.4 days on *Musa × paradisiaca*, showing a significant influence of the host ($\chi^2 = 235.6$; $df_{12, 303}$; P < 0.0001). The same was observed for viability ($\chi^2 = 140.1$; $df_{12, 399}$; P < 0.0001), which ranged from 95.4% on *C. nucifera* to 2.3% on *E. oleraceae* (Table 2).

Table 2. Immature developmental time (days) and viability (%) (Mean ± SE) of *Raoiella indica* on different hosts. Boa Vista, Roraima state, Brazil. T = 30±4,61 ºC, RH = 69±15,04%, natural light: darkness (ca. 12:12 h)

Hosts	N[a]	Developmental time	Viability
Adonidia merrillii	83	15.0 ± 0.13 g	85.3 ± 2.73 ab
Astrocaryum jauari	75	17.8 ± 0.14c	69.4 ± 4.48 bcd
Bactris simplicifrons	84	16.0 ± 0.11 ef	66.8 ± 4.87 bcd
Cocos nucifera	63	14.7 ± 0.13 g	95.4 ± 1.55 a
Euterpe oleracea	64	19.0 ± 0.0 abc	2.3 ± 1.12 f
Euterpe precatoria	30	15.4 ± 0.07 f	24.1 ± 7.28 e
Heliconia psittacorum	70	18.9 ± 0.15 b	88.9 ± 3.02 a
Mauritia flexuosa	74	17.0 ± 0.18 cd	55.0 ± 5.52 cd
Musa × paradisiaca	152	21.4 ± 0.23 a	69.6 ± 3.48 bc
Oenocarpus bacaba	47	17.3 ± 0.16 cd	39.9 ± 7.28 de
Oenocarpus bataua	43	20.3 ± 0.30 ab	25.8 ± 6.06 e
Phoenix dactylifera	75	15.9 ± 0.11 f	93.3 ± 1.73 a
Socratea exorrhiza	67	16.3 ± 0.14 e	81.1 ± 4.51 ab

Note. [a]Number of mite specimens. Means within a column followed by the same letter are not significantly different (Kruskal-Wallis test: p > 0.05).

Longevity was longer (Table 3) on *P. dactylifera* (47.3 days) and shorter on *M. flexuosa*, *Oenocarpus* spp. and *A. merrillii* (19.2-21.7 days), while oviposition was longer on *P. dactylifera* (34.4 days) and shorter on *M. flexuosa* and *Oenocarpus* spp. (9.6-12.7 days) (χ^2 = 164.9; $df_{10, 434}$; P < 0.0001), and fecundity was higher on *P. dactylifera* (25.0 eggs) and lower on *O. bataua* (5.2 ovos) and *Musa × paradisiaca* (Prata variety) (4.2 eggs) (χ^2 = 234.5; $df_{10, 460}$; P < 0.0001). However, sex ratio (proportion of females) ranged from 0.57 to 0.72, with no significant differences between plant species (χ^2 = 17.18; $df_{10, 99}$; P < 0.0705) (Table 3).

Net reproductive rate (R_0) and intrinsic rate of increase (r_m) were also affected by plant species (p < 0.05) (Table 4). The highest R_0 was on *P. dactylifera* (14.7) and the lowest on *O. bataua* (0.9), while the highest r_m was on *A. merrilliii*, *C. nucifera* and *S. exorrrhiza* (0.094-0.103) and the lowest on *O. bataua* (-0.002). Mean generation time (T) was also affected by host (p < 0.05), being shorter on *A. merrillii* (20.3 days) and longer on *O. bataua* (36.1 days) (Table 4). A significant and positive correlation was observed between r_i and r_m (n = 33; r = 0.62; p < 0.0001).

4. Discussion

Estimated instantaneous rates of increase (r_i) showed that RPM can colonize several of the evaluated plant species, both native and introduced, suggesting the ability to maintain itself in the Amazon region on wild and cultivated plants. Obviously this does not mean that the mite actually threatens those plants in nature, given that prevailing climatic factors as well as natural enemies and other biotic factors may restrain RPM from reaching high populations.

The trend for the reduction of r_i values along the duration of the experiment in several of the evaluated plant species might be spurious, being conceivably due to the progressive reduction of the suitability of the plant substrate with the increasing mite population in a restricted space (Reddall, Sadras, Wilson, & Gregg, 2004), which could lead to increasing intraspecific competition for food and space (Elkinton, 2009). Partial support to this hypothesis is the fact that for plants with lower r_i value, this parameter remained about constant (ex. *O. bataua*) or tended to increase (on *M. paradisiaca* and *O. bacaba*) during the experiment. In about half of the plants tested, RPM population decreased through time (*A. aculeatum*, *A. maripa*, *A. rosea*, *B. gasipae*, *B. maraja*, *E. guineensis*, *E. oleraceae*, *E. precatoria* and *O. bataua*), leading to the conclusion that these species are not threatened by the expanding geographic distribution of RPM in Brazil.

Table 3. Longevity (days), oviposition period (days), fecundity (eggs/female) and sex ratio (mean ± SE) of *Raoiella indica* on different plant species. Boa Vista, Roraima, Brazil. T = 30±4,61 ºC, RH = 69±15,04%, natural light: darkness (ca. 12:12 h).

Hosts	N[a]	Longevity	Oviposition period	Fecundity	Sex ratio
Adonidia merrillii	44	20.1 ± 0.65cd	13.8 ± 0.51fg	15.8 ± 0.68b	0.60 ± 0.01a
Astrocaryum jauari	46	28.0 ± 1.46b	16.8 ± 1.14cde	10.8 ± 0.70cd	0.63 ± 0.02a
Bactris simplicifrons	47	30.9 ± 1.39b	20.2 ± 1.34b	12.2 ± 1.01c	0.58 ± 0.02a
Cocos nucifera	38	27.1± 0.97b	18.6 ± 0.98bc	15.4 ± 1.08b	0.63 ± 0.08a
Heliconia psittacorum	40	26.9 ± 1.40b	15.9 ± 0.97def	10.7 ± 0.67cd	0.65 ± 0.02a
Mauritia flexuosa	55	19.2 ± 0.94d	11.0 ± 0.77h	10.2 ± 0.83d	0.62 ± 0.03a
Musa × paradisiaca	58	23.1 ± 1.65c	12.8 ± 1.19ef	4.2 ± 0.54e	0.72 ± 0.02a
Oenocarpus bacaba	34	21.7 ± 1.34cd	12.7 ± 1.03gh	10.8 ± 1.07d	0.57 ± 0.01a
Oenocarpus bataua	27	20.4 ± 1.73cd	9.6 ± 1.31h	5.2 ± 0.68e	0.61 ± 0.05a
Phoenix dactylifera	51	47.3 ± 1.79a	34.4 ± 1.45a	25.0 ± 1.04a	0.63 ± 0.01a
Socratea exorrhiza	30	26.6 ± 1.39b	17.3 ± 1.00bcd	17.6 ± 1.25b	0.60 ± 0.02a

Note. [a]Number of mite specimens. Within a column, means followed by the same letter are not significantly different (Kruskal-Wallis test: p > 0.05).

Table 4. Net reproductive rate (R_0), intrinsic rate of increase (r_m) and mean generation time (T) (mean ± CI) of *Raoiella indica* on different plant species. Boa Vista, Roraima, Brazil. T = 30±4,61 ºC, RH = 69±15,04%, natural light: darkness (ca. 12:12 h)

Hosts	N^a	$R_o [(♀)(♀)^{-1}]$	$r_m [(♀)(♀)^{-1}(day)^{-1}]$	T (days)
Adonidia merrillii	44	8.1(7.4-8.8) b	0.103(0.099-0.107) a	20.3(19.9-20.7) a
Astrocaryum jauari	46	4.7(4.1-5.3) c	0.061(0.056-0.066) c	25.3(24.3-26.2) b
Bactris simplicifrons	47	4.7(3.9-5.5) cd	0.065(0.058-0.071) c	24.0(23.1-25.0) b
Cocos nucifera	38	9.2(7.9-10.5) b	0.097(0.092-0.103) ab	22.9(22.0-23.7) b
Heliconia psittacorum	40	6.2(5.4-7.0) c	0.065(0.060-0.069) c	28.1(27.3-28.9) c
Mauritia flexuosa	55	3.5(2.9-4.2) d	0.058(0.050-0.065) c	22.1(21.3-22.9) b
Musa × paradisiaca	49	2.1(1.6-2.6) e	0.028(0.018-0.038) d	26.9(26.0-27.8) c
Oenocarpus bacaba	34	2.0(1.5-2.5) e	0.030(0.020-0.040) d	23.7(22.7-30.8) bcd
Oenocarpus bataua	27	0.9(0.7-1.2) f	-0.002(-0.009-0.006) e	36.1(33.1-39.2) e
Phoenix dactylifera	51	14.7(13.5-15.9) a	0.090(0.087-0.093) b	30.0(29.2-30.9) d
Socratea exorrhiza	30	9.0(7.7-0.3) b	0.094(0.087-0.100) ab	23.4(22.6-24.2) b

Note. [a]Number of mite specimens. Within each column, means followed by the same letter are not significantly different (T test: P > 0.05).

The reasons for those different levels of susceptibility are not known, but could be due to plant defense factors (Painter, 1958; Price, 1986; Stout, 2013). According to Isman and Grieneisen (2014) plants developed complex chemical arsenals (terpenoids, flavonoids, tannins and alkaloids) with phytochemical activities that can act as deterrents to feeding or oviposition, reducing the performance of herbivores (Novaes, Molinillo, Varela, & Macías, 2013; Pavela, 2010; Rattan, 2010). Variability of leaf structures can also provide mechanical or physiological characteristics that can interfere with the ability of a particular mite species to use a plant as host. In palm trees, such structures can be scales of the abaxial leaf surface, presence of epicuticular wax, as well as the presence of trichomes in different densities (Beard et al., 2012; Horn, Fisher, Tomlinson, Lewis, & Laubengayer, 2009; Valverde, Fornoni, & Núñez-Farfán, 2001). Another important aspect concerning RPM refers to the characteristics of the stomata. Beard et al. (2012) mentioned that this mite feeds by piercing cells inside the stomata. These authors showed that feeding by RPM is greatly influenced by the behavior of the stomata, and that *Raoiella* species cannot feed on hosts with closed or covered stomatal openings.

Results of the present study suggest that native Brazilian plant species (*A. jauari*, *B. simplicifrons*, *M. flexuosa*, *O. bacaba*, *S. exorrhiza* and *H. psittacorum*) could be at risk with the expansion of the distribution of RPM, given that the values of r_i for those species are similar to the values obtained for well known exotic hosts, as *A. merrillii* and *C. nucifera* (Carrillo et al., 2012; Vásquez et al., 2015). However, quite different life table parameters were found in this and previous studies. The value of r_m was much higher on *A. merrillii* in this study than reported by Vásquez et al. (2015) at a slightly lower temperature (29 ºC; r_m = 0.042, against 0.1 in this study). This difference could be due to the fact that in the present study the rearing units were established on undetached leaves, which would supposedly be more adequate for not promoting the closure of the stomata (Beard et al., 2012). However, quite the opposite was found on *C. nucifera*, for which those authors reported r_m of 0.166 (against 0.097 in this study). Thus, detachment of leaves may disturb RPM performance, but obviously other factors might have important bearing as well. In any case, in both studies *C. nucifera* and *A. merrillii* were the hosts on which *R. indica* best performed.

The intrinsic rate of natural increase (r_m) value is used for revealing the impact of a parameter (*e.g.* temperature, host plant) on the demographic potential of an organism (Birch, 1948; Dent, 1997). Under optimum conditions, r_m will attain its maximum possible value (Dent, 1997). Meanwhile, the instantaneous rate of increase (r_i) measures the ability of a population to increase over time (Hall, 1964). Walthall and Stark (1997) considered that r_i provides information on short-term and real populations are evaluated in shorter time and at less expense than the traditional life table method. These authors obtained high correlation between these two demographic parameters (r^2 = 0.91, n = 21, $p < 0.01$) for populations of pea aphid, *Acyrthosiphon pisum* (Harris) (Hemiptera: Aphididae), used as the model species and exposed to the nicotinergic insecticide imidacloprid, as xenobiotic sprayed on potted broad bean, *Vicia faba* L. (variety Banner), suggesting that r_i can be used as a substitute measure for r_m. The r_i has been used in the assessment of xenobiotics, especially concentration-response laboratory bioassays (Stark et al., 1997; Tuelher, Venzon, Guedes, & Pallini, 2014; Walthall & Stark, 1997).

All native plant species classified as potential primary hosts of RPM in this study (*A. jauari*, *B. simplicifrons*, *M. flexuosa*, *O. bacaba*, *S. exorrhiza* and *H. psittacorum*) have great relevance to indigenous people, for extractivism and/ or maintenance of wildlife of the Amazon biome, providing important elements as food, construction items, shelter, medicine, handcraft raw material, fibers etc. (Mesa & Galeano, 2013; Paniagua-Zambrana et al., 2007; Sosnowska & Balslev, 2009). Some of the palm species, as *S. exorrhiza*, are among the 20 most abundant plants in the Amazon biome (Steege et al., 2013). Many of these palms are found in conservation areas, where mite control is difficult to apply. The conceivable significant role of prevailing natural enemies on RPM population on those plants remains to be demonstrated. These could eventually prevent RPM from causing significant damage to those hosts. The study of these and related aspects is warranted.

In conclusion, the red palm mite has the potential to cause severe damage to plants native to the Brazilian Amazon. Eight species were concluded in this study to be potential primary hosts, of which five are native to that biome, namely the Arecaceae *A. jauari*, *B. simplicifrons*, *M. flexuosa* and *S. exorrhiza*, and the Heliconiaceae *H. psittacorum*. This seems relevant, because all of these species are important for extractivism by indigenous people and/or for maintenance of wildlife.

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