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Peacock mites on cannon-ball tree, *Couroupita guianensis* (Lecythidaceae) in the Southeast Region of Brazil

Hector Alonso Escobar-García ^{a,b}, Daniel Júnior de Andrade ^a, Jennifer J. Beard ^c, Ronald Ochoa ^d

^a São Paulo State University (UNESP), School of Agricultural and Veterinary Sciences, Jaboticabal, Brazil.

^b Facultad de Agronomía, Universidad Nacional de Piura (UNP), Piura, Peru.

^c Queensland Museum, P.O. Box 3300, South Brisbane, Qld 4101, Australia.

^d Systematic Entomology Laboratory, United States Department of Agriculture, Agricultural Research Service, Beltsville, MD 20705, USA.

Original research

ABSTRACT


Tuckerella ornata, *Tuckerella knorri* (Acari: Tuckerellidae) and *Brevipalpus yothersi* (Acari: Tenuipalpidae) were found associated with the native South American Cannon-ball tree, *Couroupita guianensis*, for the first time in Brazil. The trees were observed throughout their flowering season in spring for two consecutive years. The highest population densities of peacock and flat mites were located on the raceme-type inflorescences. Throughout this survey, no mites were detected on the fruits.

Keywords Trombidiformes; Tetranychoida; Amazon Region; landscape; forest tree

Introduction

The peacock mites, *Tuckerella ornata* (Tucker) and *Tuckerella knorri* Baker & Tuttle (Acari: Tetranychoida: Tuckerellidae), are found in many parts of the world and have been collected from a wide variety of taxonomically diverse host plants. To date, these two mites have been documented in three South American countries: Brazil (Flechtmann 1979; Barbosa *et al.* 2003; Da Silva *et al.* 2023; Melo *et al.* 2024), Venezuela (Camacho *et al.* 2002), and Peru (Escobar-García *et al.* 2021a). They are both small, reddish-orange mites that feed on fruit and the bark of stems and branches. They are obvious to the naked eye with their large broad white setae contrasting against their red bodies. In addition, they have a row of long flagellate setae along their posterior margin which makes them easily identifiable (Ewing 1922; Ochoa 1989; Beard and Walter 2005; Escobar-García *et al.* 2021a; Escobar-García *et al.* 2022). They move slowly and are frequently observed resting on the fruit rind or in depressions and cracks in the bark of their host plant. These mites are able to puncture exposed green periderm tissue of tree branches with their paired stylet mouthparts for feeding (Corpuz-Raros 2001; Beard *et al.* 2012; Childers *et al.* 2018; Escobar-García *et al.* 2021a; Escobar-García *et al.* 2022; Da Silva *et al.* 2023). These mites are playing an increasingly significant role in quarantine and agriculture as pests of economic importance, as our understanding of their biology, distribution, and ecology expands (Escobar-García *et al.* 2021a; Escobar-García *et al.* 2022; Da Silva *et al.* 2023). It should be noted that not only are these two mites known to occur outside of the Americas, but a sizable portion of their host plants across the world are native to the Americas, including cocoa (Flechtmann 1979; Escobar-García *et al.* 2021a; Da Silva *et al.* 2023), guava (Camacho *et al.* 2002), and Barbados Cherry (Barbosa *et al.* 2003).

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Corresponding author
Hector Alonso Escobar-García 
hescobarg@unp.edu.pe

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The tree *Couroupita guianensis* Aubl., a member of the endemic South America family Lecythidaceae, grows quickly and can reach heights of up to 35 meters. Known as the “cannon-ball tree” due to shape of its fruit, the tree is naturally distributed across northwestern South America. Known in Brazil as “macacarecuia”, “abricó-de-macaco”, and “castanha-de-macaco”, it is a large deciduous tropical tree that is popular for its ornamental and medicinal uses. The fruits are consumed locally (Nelson *et al.* 1937; Kavitha *et al.* 2011; Uppala *et al.* 2016) and used in preparation of medicinal drinks (Pinheiro *et al.* 2013) to relieve symptoms of colds, and head and stomach aches. Due to the antibacterial and antifungal properties, preparations are also used to treat wounds (Prabhu and Ravi 2017; Reshma *et al.* 2018; Sheba and Anuradha 2020). With large, beautiful dark reddish-pink and white flowers and pleasant fragrance, it is frequently planted alongside roads and in gardens (Mori *et al.* 2007; Rajput and Patil 2016; Raghavendra *et al.* 2017; Sheba and Anuradha 2020). The alternate, oblong or oblong-ovate leaves are grouped at the tips of the branches, are rounded to obtuse at the tip and attenuate at the base, with a short petiole. The inflorescence is a cauliflorous raceme that develops from the trunk and lower branches, and in Southeast Brazil flowering occurs primarily in the spring. Fruits are firm on the outside, brown, and globose, measuring up to 25 cm in diameter and weighing up to 16 kg each. Pulp fills the entire shell and the external colour reflects the level of maturity. The fruit has a white, vinous, and acidic pulp with many seeds (200–300). When the creamy pulp is exposed to air, it oxidizes and turns bluish-green, and has a foul odour due to a high concentration of sulphur compounds (Rajput and Patil 2016; Raghavendra *et al.* 2017; Sheba and Anuradha 2020). Despite this, the tree has significant economic, social and environmental value, as products derived from the leaves, flowers and bark are used in pest and disease control, in addition to ethnomedicine (Pinheiro *et al.* 2010; Baskar *et al.* 2015; Anu and Mendhulkar 2015; Raghavendra *et al.* 2017; Sheba and Anuradha 2020; Ferreria *et al.* 2021; Babu *et al.* 2022; Esposito *et al.* 2023; Escobar-Garcia *et al.* 2024a; CABI 2024). Here, two peacock mite species and one flat mite are reported on *C. guianensis* in Brazil for the first time.

Material and methods

Mites were collected every two weeks in the spring and summer of 2022 and 2023 from four *C. guianensis* trees on the campus of São Paulo State University (UNESP), Jaboticabal, Brazil (21°14'50.28" S, 48°17'51.85" W; 588 m a.s.l.) (Fig. 1). According to the international Köppen climate classification, the region is a humid subtropical zone with dry winters and hot summers *Cwa* (Beck *et al.* 2018). The temperature, relative humidity, and rainfall parameters utilized in this study were sourced from a database belonging to the Agroclimatological Station - Department of Exact Sciences, UNESP, Jaboticabal, São Paulo, Brazil (21°14'05" S, 48°17'09" W; 615 m.a.s.l.). The sampling process for each tree consisted of a random collection of 20 leaves, two raceme-type inflorescences, and fruits: five immature fruits in the spring and two developed fruits in the summer. Samples were kept in separate paper bags and transported to the Acarology laboratory (AcaroLab) at the UNESP. A Berlese funnel was used to extract mites from the developed fruits collected in summer. Mites were collected using a fine-tipped brush under an Olympus SZ61 stereomicroscope. They were then mounted dorsoventrally on microscope slides in Hoyer's media and baked for 7 days at 50 °C (Walter and Krantz 2009). Finally, the slides were sealed with nail polish. Mite morphology was studied using a Nikon Eclipse E200 phase-contrast compound microscope with an ocular micrometer, and a variety of taxonomic keys (Chant 1959; Denmark and Muma 1970; Meyer and Ueckermann 1997; Matioli *et al.* 2002; Beard *et al.* 2015; Da Silva *et al.* 2016; Rehman *et al.* 2018; Mirza *et al.* 2022; Lofego *et al.* 2024). Images were taken with a Nikon Eclipse 80i with Capture 2.3 imaging software. The microscope slides are deposited in ESALQ—Department of Entomology and Acarology, Luiz de Queiroz College of Agriculture, University of São Paulo (USP), Brazil; NMNH—National Insect and Mite Collection, National Museum of Natural



Figure 1 Cannon-ball tree, *Couroupita guianensis* Aubl. (Lecythidaceae): **A** – Adult tree; **B** – Detail of the leaves; **C**– Detail of the raceme-type inflorescences, with insertion of detail of the flower; **D** – Detail of the fruits.

History, Smithsonian Institution, located at the Systematic Entomology Laboratory (SEL), USDA, Beltsville, MD, USA; and QM—Queensland Museum, Brisbane, Australia.

The influences of maximum and minimum temperatures, mean relative humidity, and mean rainfall on the population density of *T. ornata*, *T. knorri* and *Brevipalpus yothersi* Baker (Acari: Tenuipalpidae) were evaluated using Multivariate Analysis (MVA) and Principal Component Analysis (PCA). The average number of individuals of each species collected from raceme-type inflorescences during the study was used to calculate species abundance. Maximum and minimum temperatures, mean relative humidity, and mean rainfall were averaged over the 14 days preceding the sampling date and were included in the analysis. The average numbers of each developmental stage of each species, were compared by year, following subsection to the Shapiro-Wilk test to verify normality ($p > 0.05$). The data met this requirement and the Student's

t test was subsequently conducted. The StatGraphics Centurion XVIII program (StatGraphics 2009) was used to assess any relationships between these groupings. The significance level of 5% was used in all statistical analyses.

Results and discussion

We report the first detection of the peacock mites *T. ornata* and *T. knorri* on *C. guianensis* trees in Brazil (Fig. 2), although these two species are known in the Brazilian state of Pará, commonly on cacao, *Theobroma cacao* L. (Malvaceae) (Flechtmann 1979; Da Silva *et al.* 2023). They have also been found to cause significant damage to cocoa fruit in Piura, Peru, resulting in a reduced harvestable yield of seeds (Escobar-Garcia *et al.* 2021a). Additionally, *T. ornata* was collected in Zulia, Venezuela, on guava, *Psidium guajava* L. (Myrtaceae) (Camacho *et al.* 2002); and *Malpighia emarginata* D.C. (Malpighiaceae) in Pernambuco, Brazil (Barbosa *et al.* 2003).

Tuckerella ornata (Fig. 3A) and *T. knorri* were only observed on the raceme-type inflorescences of the cannon-ball tree and were collected in each spring for two consecutive years. The combined population densities of peacock mites were 3.60 to 4.35 eggs, 1.45 to 2.38 immature stages, and 1.53 to 1.83 adult females. Immature stages of peacock mites (both species combined) were negatively correlated with average minimum (> 18.3 °C) temperature ($r = -0.65$, $n = 10$, $p = 0.04$). The densities of females of *T. knorri* were also negatively correlated with average minimum (> 18.3 °C) temperature ($r = -0.68$, $n = 10$, $p = 0.02$). However, densities of female *T. ornata* were positively correlated with maximum ($r = 0.62$, $n = 10$, p

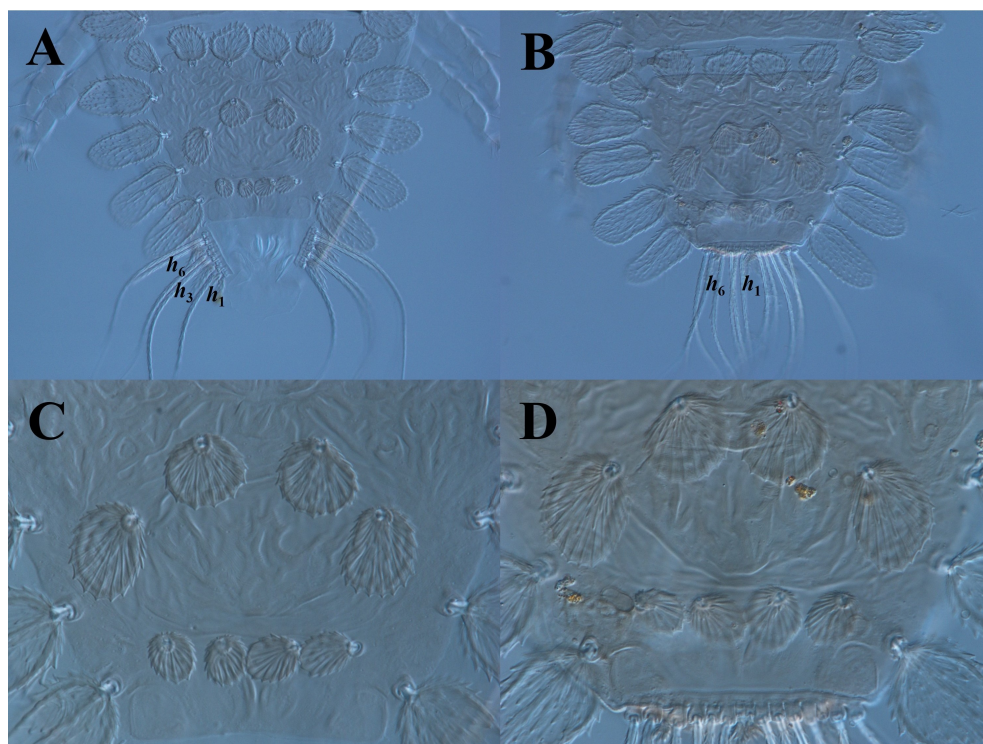


Figure 2 Peacock mites on Cannon-ball tree: **A** – *Tuckerella ornata* with three pairs of short, broad ovate setae (h_1 , h_3 , and h_6) and five pairs of equal-length elongate flagellate caudal setae (h_2 , h_4 , h_5 , h_7 , and h_8); **B** – *Tuckerella knorri* with two pairs of short, broad ovate setae (h_1 and h_6) and six pairs of equal-length elongate flagellate caudal setae (h_2 , h_3 , h_4 , h_5 , h_7 , and h_8); **C** – *T. ornata* with cuticle with reticulations that tend to be regular; **D** – *T. knorri* has reticulation that is irregular and finely areolate in its cuticle.



Figure 3 Mites on raceme-type inflorescences on Cannon-ball tree: **A** – Details of female and egg *T. ornata*; **B** – Detail of a female of *B. yothersi*.

= 0.05) and minimum ($r = 0.53, n = 10, p = 0.11$) temperatures; i.e., the density of female *T. ornata* increased with maximum ($> 33\text{ }^{\circ}\text{C}$) and minimum ($> 20\text{ }^{\circ}\text{C}$) temperatures; however, the p -value that tests the statistical significance of the estimated correlations was greater than 0.05.

Although Figure 4 presents data indicating that densities of female *T. ornata* and *T. knorri* were affected by rainfall, there is only a very low and non-significant negative correlation for *T. ornata* ($r = -0.09, n = 10, p = 0.79$), and a moderate and non-significant negative correlation

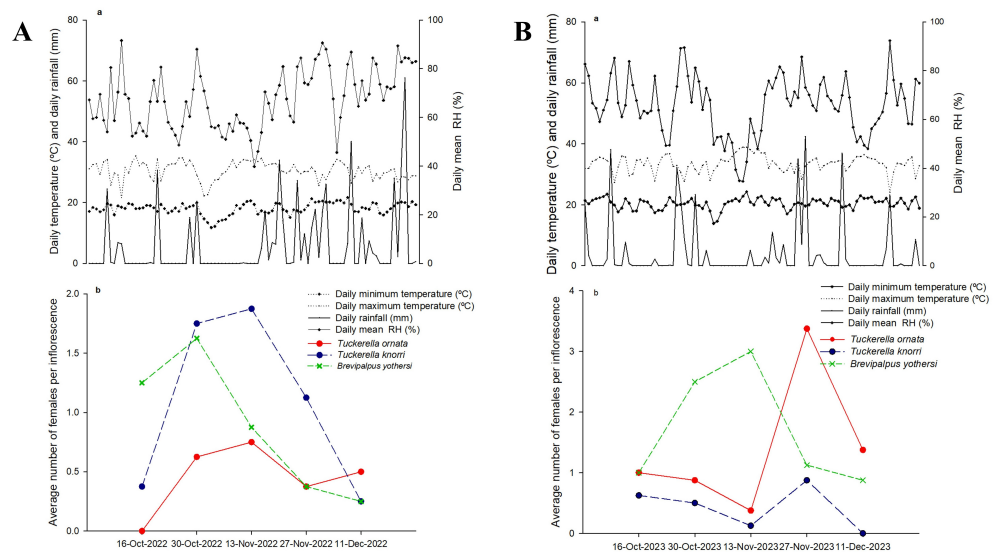


Figure 4 **A** – The climatic data and population fluctuation of females during spring 2022; **B** – The climatic data and population fluctuation of females during spring 2023.

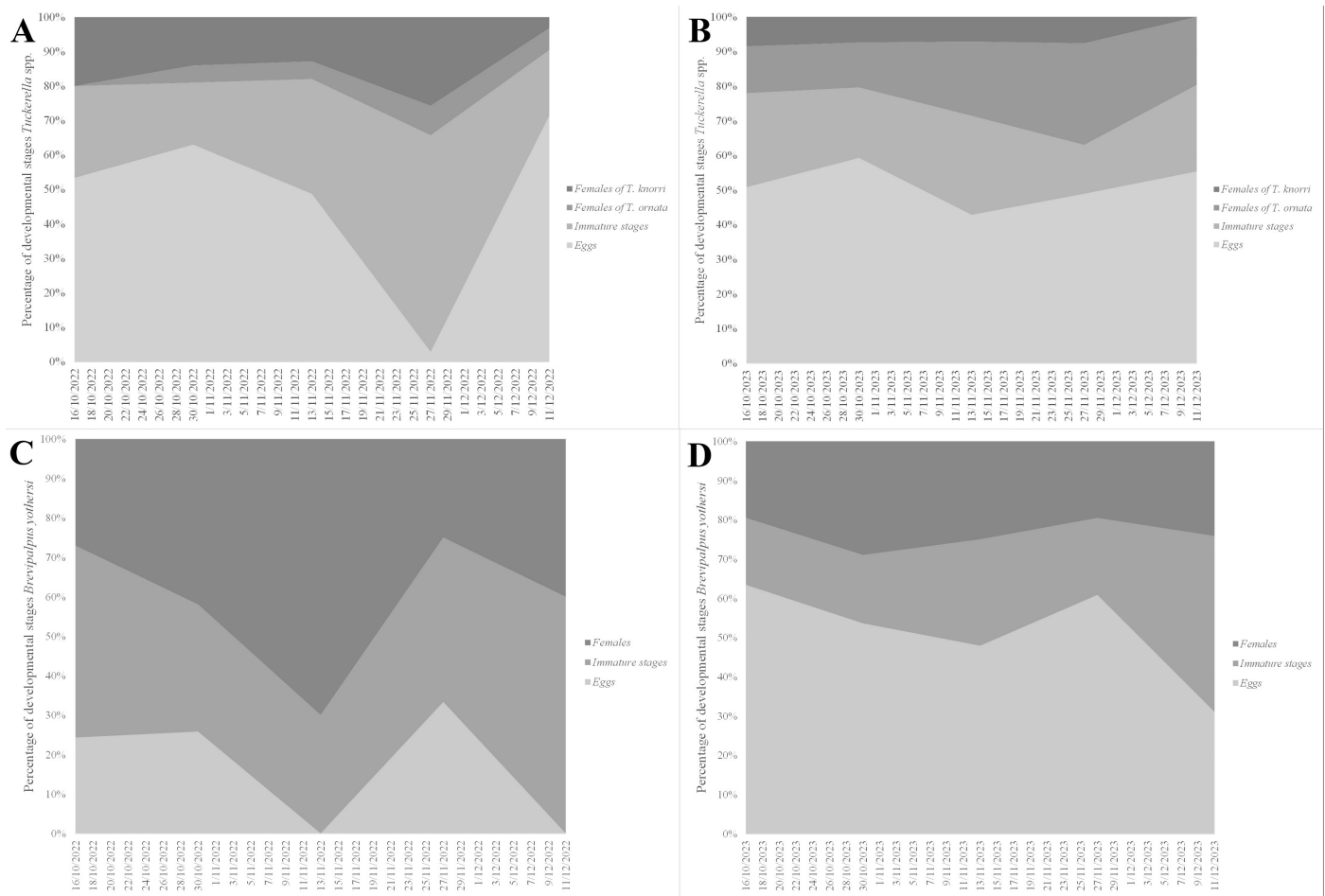


Figure 5 Development in the age structure of females, motile immatures stages, and eggs of peacock and flat mites in spring on *C. guianensis*: **A** – Development in the age structure of *Tuckerella* spp. in 2022; **B** – Development in the age structure of *Tuckerella* spp. in 2023; **C** – Development in the age structure of *B. yothersi* in 2022; **D** – Development in the age structure of *B. yothersi* in 2023.

for *T. knorri* ($r = -0.47, n = 10, p = 0.16$). No significant correlations were detected between the other developmental stages of peacock mites and climatic variables. The PCA of climatic variables and the densities of peacock mites showed that the first component represents about 43.0% of the total variability and the second an additional 28.1%. In the first component, high values of minimum temperature ($> 18.3\text{ }^{\circ}\text{C}$) negatively affected the densities of immature stages of peacock mites, and females of *T. knorri*. While in the second component maximum and minimum temperatures were positively related with densities of females of *T. ornata*. Although each stage of development of both species of peacock mites was present in each year studied, we found no significant difference between the means of the two data samples, with a confidence level of 95.0% (t test, eggs: $t = 0.42, p = 0.68$; immature stages: $t = 1.19, p = 0.26$; females of *T. ornata*: $t = -1.77, p = 0.11$; and females of *T. knorri*: $t = 1.73, p = 0.12$). Eggs and immature stages combined, were more abundant than females in all the evaluations, ranging from 63% to ~90% of individuals depending on the evaluation date (Figs. 5A and 5B). Maximum values of females were observed on November 27 for both years ranging from 34% to ~37% of the general population of peacock mites (Figs. 5A and 5B).

Plant-feeding mites can detect the developmental state of their host via its cell chemistry; therefore, mites on the branches, main trunk, and possibly roots, would detect that flowers are developing and begin to migrate to the racemes for potentially more nutritious food. Interestingly, although *Tuckerella* species are known to not only feed on, but also to favour

feeding on, the fruits of their hosts (Beard *et al.* 2013), neither of the species studied here used the crevices on the epicarp of the fruits for feeding, oviposition, or protection. The fruits are known to contain a range of toxic chemical constituents, including campesterol, couroupitine A (tryptanthrin), couroupitine B (indirubin), farmaricetin, hopane, isocitric acid, kaempferol, luteolin, malic acid, quercetin, rutin, stigmaterol, sulphur, and ursolic acid (Sen *et al.* 1974; Regina and Uma Rajan 2012; Gupta *et al.* 2014; Sheba and Anuradha 2020), which could be acting to deter the mites from inhabiting the fruit. Although we did not study the fruit chemistry and its influence on these mites, we hypothesized that more than one component may be involved in deterring the mites. During these two years of survey, no peacock mites were observed on either the leaves or ripe fruit.

There are few studies regarding the mite diversity on cannon-ball trees. To date, there are records of the spider mite *Tetranychus mexicanus* (McGregor) (Tetranychidae) (Flechtmann 1967; Migeon and Dorkeld 2024), and the flat mite *Tenuipalpus couroupita* De Leon (Tenuipalpidae) (De Leon 1967; Castro *et al.* 2024). In addition, the arboreal predator *Amblyseius largoensis* (Muma) (Phytoseiidae) has also been recorded from this tree (Calcavante *et al.* 2021; Demite *et al.* 2024). Here we report the flat mite *B. yothersi* for the first time from this host (Fig. 3B). The aggregations of *B. yothersi* were more common, and the population densities were much higher on the inflorescence (0.5 to 3.7 eggs, 1.0 to 1.7 immature stages, 0.9 to 1.7 females) than on the leaves (0.0 to 0.1 eggs, 0.0 to 0.2 immature stages, 0.0 to 0.2 females).

Densities of *B. yothersi* eggs were positively correlated with average maximum temperature ($r = 0.69$, $n = 10$, $p = 0.02$); i.e., the densities of eggs increased with increasing maximum temperature (> 30.7 °C), and also with average minimum temperature ($r = 0.53$, $n = 10$, $p = 0.10$), but the latter was not statistically significant ($p > 0.05$).

Densities of female *B. yothersi* were affected by the average relative humidity ($r = -0.47$, $n = 10$, $p = 0.16$), and rainfall ($r = -0.45$, $n = 10$, $p = 0.18$); i.e., the densities of females decreased with increasing averages of relative humidity and rainfall, with a moderate and non-significant negative correlation observed in both analyzes ($p > 0.05$). According to the PCA of *B. yothersi* mite numbers and climate factors, the first component accounts for roughly 54.7% of the overall variability, while the second contributes an additional 27.9%. In the first component, the density of eggs was associated with the average maximum temperatures. We found a significant difference between the densities of eggs of *B. yothersi* in 2022 versus eggs in 2023, with a confidence level of 95.0% (t test, eggs: $t = -3.87$, $p = 0.00$); i.e., the densities of eggs were higher in the year 2023. No significant differences were found for the other developmental stages of *B. yothersi* ($p > 0.05$).

The densities of eggs and immature stages of *B. yothersi* exceeded that of adult females, varying from 30% to ~80% of the total densities of mites based on the evaluation date (Figs. 5C and 5D). On November 27, minimum values of females ranged from 20 to nearly 25% of the overall *B. yothersi* population for both years (Figs. 5C and 5D). Maximum numbers of female peacock mites were observed on this same date, which could result in peacock mites dominating territory and feeding sites over *B. yothersi*, i.e., densities of females of *B. yothersi* could be affected by the densities of female peacock mites ($r = -0.50$, $n = 10$, $p = 0.13$), and this moderate negative but non-significant correlation ($p > 0.05$) was observed during all evaluations (Fig. 5).

During this study, the predatory mites *Euseius citrifolius* Denmark & Muma, and *Euseius concordis* (Chant) (Phytoseiidae); *Agistemus brasiliensis* Matioli, Ueckermann & Oliveira (Stigmaeidae); and *Brachytydeus formosus* (Cooreman) (Tydeidae) were found on leaves on the cannon-ball tree. *Neophyllobius* (*Neophyllobius*) *unespensis* Escobar-Garcia & Ueckermann (Camerobiidae) were also found on the inflorescences (Escobar-Garcia *et al.* 2024b).

This association between the species *T. ornata*, *T. knorri* and *B. yothersi* has also been observed on cocoa fruits in Peru, during the same season (spring) and a similar phenological phase of plant development (Escobar-Garcia *et al.* 2021b). *Tuckerella ornata*, *T. knorri*, and *B. yothersi* are economically important mites that feed on fruit and ornamental trees, and their

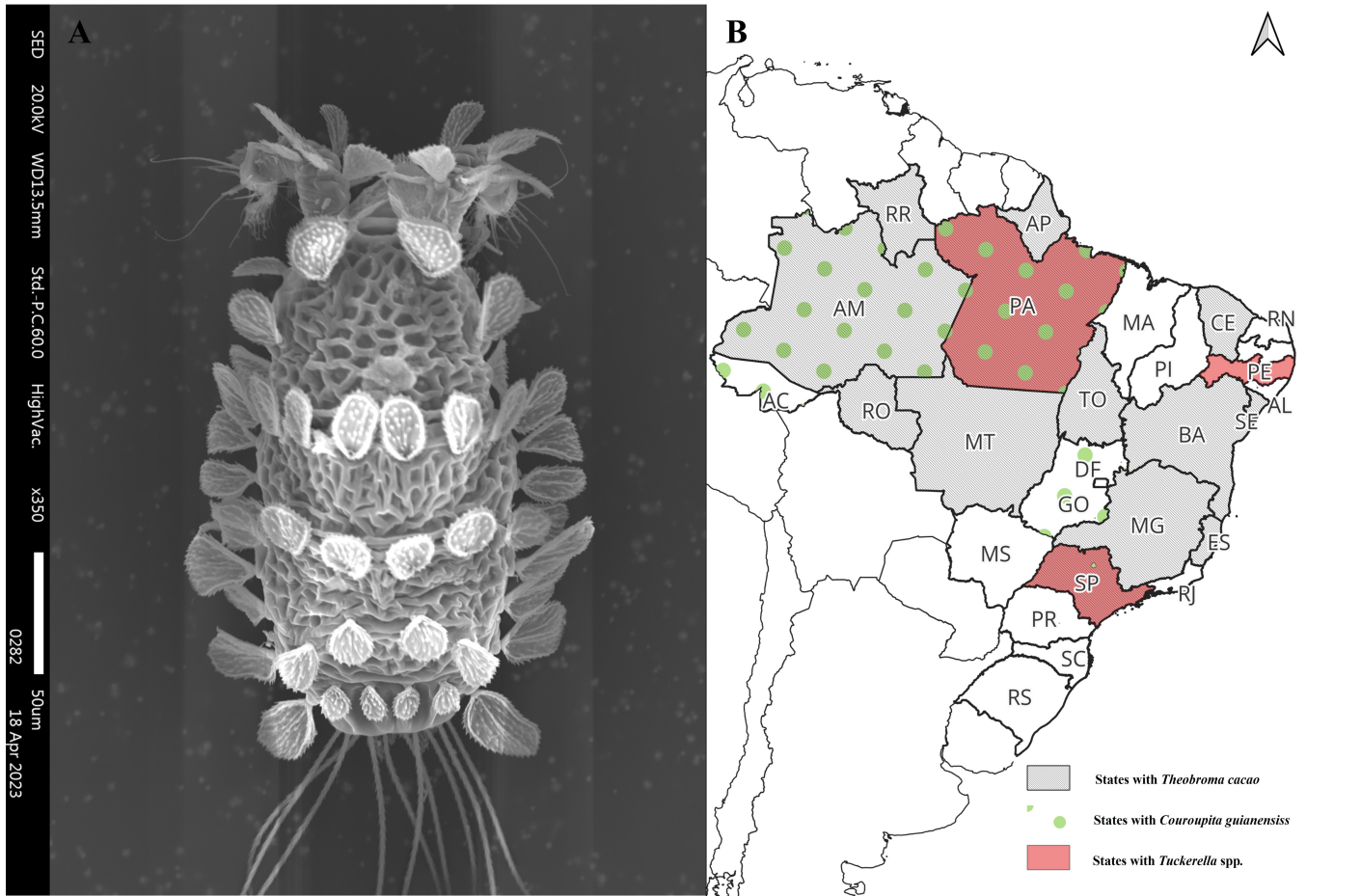


Figure 6 Current *Tuckerella* spp. distribution in Brazil. **A** – female of *T. ornata*; **B** –Geographic distribution of *C. guianensis* on Brazil—the North (Acre, Amazonas, Pará), Central-West (Goiás) (Cabello *et al.* 2024); Geographic distribution of *T. cacao* on Brazil, main producing regions (Pará, Bahia, Espírito Santo, Rondônia, Amazonas, and Mato Grosso), and new production areas (Roraima, Amapá, São Paulo, Ceará, Sergipe, Minas Gerais, and Tocantins) (CEPLAC 2022, <<https://www.gov.br/agricultura/pt-br/assuntos/ceplac>>).

presence on *C. guianensis* in Brazil is of potential concern. The geographic distribution of *C. guianensis* in northern Brazil (Acre, Amazonas, Pará) (Fig. 6B) coincides with primary cocoa-producing states, and its presence as an alternative host could negatively impact cocoa cultivation in agroforestry systems, and we believe it to be of phytosanitary significance in the states of Pará, Amazonas, and Rondonia. Economically significant damage has already been reported in cocoa cultivation in Pará (Da Silva *et al.* 2023), and cocoa farmers in these regions should consider control strategies within Integrated Pest Management programs that carefully monitor for these mites. An important tool for farmers in their efforts would be 16X-20X hand lenses that allow them to detect the mite’s presence. It is important to advocate for increased awareness of the domestic movement of leaves and inflorescences for ethnomedical purposes of *C. guianensis*, in addition to monitoring the primary cocoa-producing areas for these three mite species.

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Phytoseiidae mite species. We would also grateful Department of Entomology and Acarology, ESALQ, USP, Brazil for the help with the figures of *Tuckerella* morphology. To Aline Tassi (UF, USA) and Thiago Feliph Silva Fernandes (UNESP, Brazil) for preparing Figure 6A and 6B, respectively. We would our appreciation also goes to Gerson La Rosa (UDEP, Peru) for the statistical support. We wish to express our special thanks to Andrew Ulsamer (ARS-USDA) for the revision and suggestions to the manuscript. This study was financed in part by the Coordination of Superior Level Staff Improvement (CAPES), Brazil. To the Smithsonian Natural History Museum (NMNH) and National Agricultural Library (NAL-USDA), SEL-USDA for support and assistance with specimens and references. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA. USDA is an equal opportunity provider and employer.

ORCID

Hector Alonso Escobar-Garcia  <https://orcid.org/0000-0002-5003-2268>
 Daniel Júnior de Andrade  <https://orcid.org/0000-0003-0054-879X>
 Jennifer J. Beard  <https://orcid.org/0000-0003-0734-1011>
 Ronald Ochoa  <https://orcid.org/0000-0003-1680-3601>

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