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Invasion of the main cocoa-producing region of South America by *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae)

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Maconellicoccus hirsutus (Green) (Hemiptera: Pseudococcidae), the pink hibiscus mealybug, is an invasive mealybug that has been recorded from numerous plant species (over 350 species in 75 families), and is a potential pest of many agricultural crops as well as a threat to native plants in biologically diverse areas such as the Neotropics (Kairo et al. 2000; García Morales et al. 2016). Economically important crops throughout the world, such as cotton and grape, are hosts of *M. hirsutus*, but it apparently prefers plants of the family Malvaceae (Meyerdirk et al. 2001; Goolsby et al. 2002; Vitullo et al. 2009). Although it is now found in all biogeographic regions except the Antarctic, *M. hirsutus* invaded the Caribbean relatively recently and subsequently North America and Caribbean South America, including Colombia, French Guiana, Guyana, Suriname, and Venezuela (Kairo et al. 2000; Culik et al. 2013a). First detected in northern Brazil in 2010, *M. hirsutus* has spread to northeastern, southeastern, and central western regions, where it has been found on host plants in the families Anacardiaceae, Annonaceae, Fabaceae, Malpighiaceae, Malvaceae, Myrtaceae, Oxalidaceae, Rutaceae, and Solanaceae (Broglio et al. 2015; Peronti et al. 2016). Although *M. hirsutus* has previously been recorded from cocoa (*Theobroma cacao* L.; Malvaceae), there is no published study documenting its damage to this economically and socially important crop (Kairo et al. 2000). Therefore, the objective of this research was to document the recent range expansion of *M. hirsutus* into the main cocoa production region of South America, located in the states of Bahia and Espírito Santo, Brazil (IBGE 2015; FAO 2016) and to evaluate and describe the signs of *M. hirsutus* infestation and damage to cocoa.

Cocoa plantations (n = 460) were sampled from Feb 2013 to Feb 2014 in 87 municipalities of the 3 main cocoa production regions of Bahia: Recôncavo Baiano (n = 6), southern region (n = 40), and extreme south (n = 11); and in northern (n = 15) and southern (n = 15) Espírito Santo, Brazil, to determine the distribution of *M. hirsutus* in these areas. Samples of cocoa stems, shoots, leaves, flowers, and fruits with mealybugs were collected from infested cocoa plants. Mealybugs and natural enemies in the samples were preserved in 70% alcohol and sent to collaborating taxonomists for confirmation of identifications of the insects collected.

Maconellicoccus hirsutus was identified in 27 infested cocoa samples from 24 locations in 13 municipalities of Espírito Santo (2 samples also contained *Planococcus minor* Maskell; Hemiptera: Pseudococcidae). *Maconellicoccus hirsutus* was also found on cocoa in 2 municipalities of the extreme south, and 6 of the Recôncavo Baiano regions of Bahia. No *M. hirsutus* was found in the southern cocoa producing region of Bahia during this research (Fig. 1). Thus, at the start of this study in Feb 2013, 9 mo after the initial detection of *M. hirsutus* in southeastern Brazil (Culik et al. 2013b), this mealybug was observed for the first time on cocoa in South America, on plants of cocoa in northern Espírito Santo in the municipality of Linhares (19.481644°S, 39.926136°W), and at the conclusion of this research, 1 yr after its initial detection on cocoa in this region, *M. hirsutus* had become widespread in cocoa plantations in Espírito Santo and Bahia.

Adult females covered with white, powdery wax, nymphs, and reddish ovisacs with large numbers of eggs were observed in all parts of the canopy of *T. cacao* plants sampled in this research, including shoots, leaves, and fruits (Figs. 2–8). Large numbers of ovisacs, nymphs, and adults (Fig. 2) were noted on shoots, particularly on new growth, and on cocoa fruits at different stages of development. The mealybugs damaged cocoa shoots, with development of sooty mold on young (6 mo to 2 yr old) (Figs. 3 and 4) and 4- to 5-yr-old plants, as well as cocoa flowers (Figs. 5 and 6) and fruits (Figs. 7 and 8). *Maconellicoccus hirsutus* infestation was associated with cocoa leaf curling and deformation, and infested growing points of cocoa plants were stunted and swollen with severe crumpling of leaves. Heavy infestations were associated with de-

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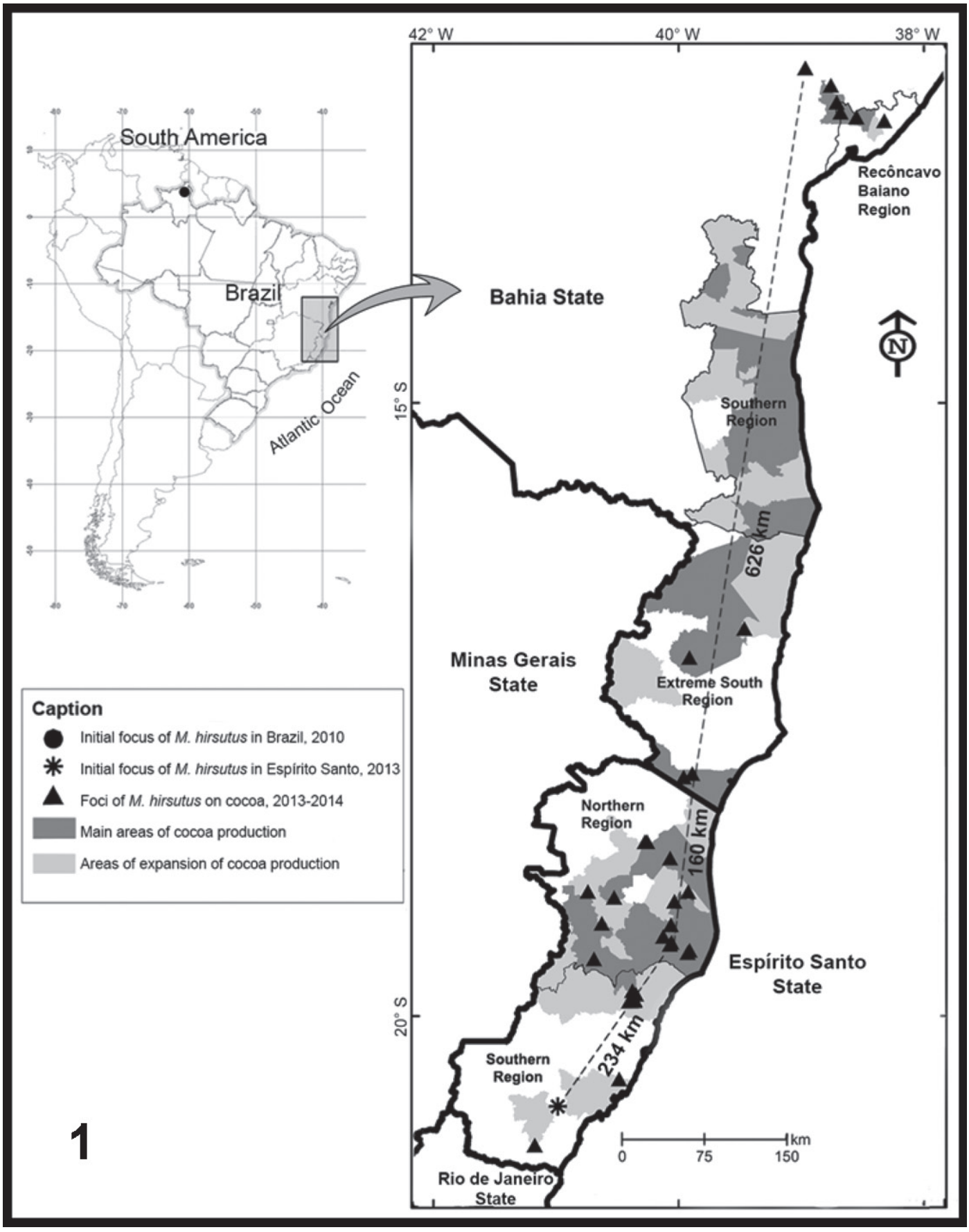
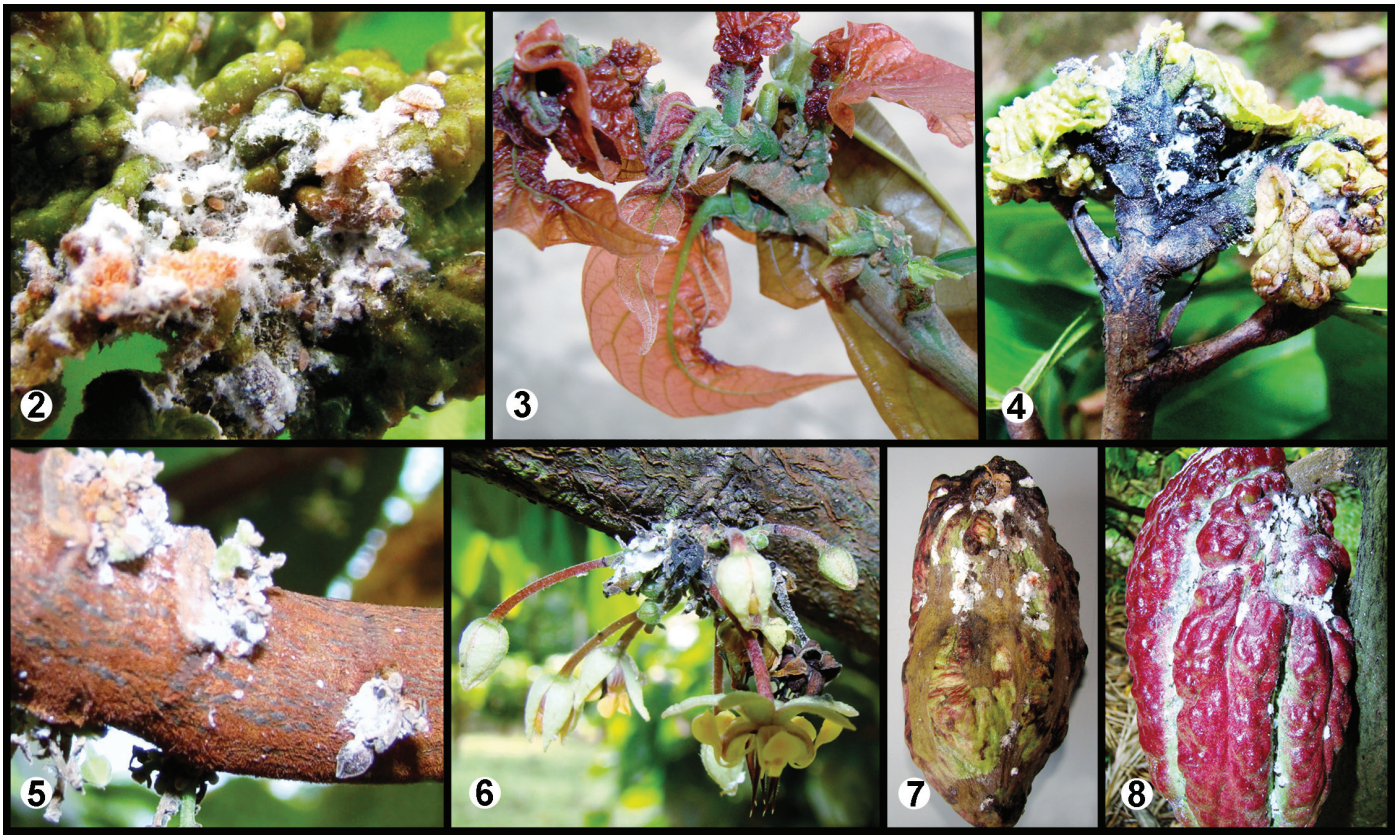


Fig. 1. Range of *Maconellicoccus hirsutus* in cocoa orchards in the states of Bahia and Espírito Santo, Brazil, Feb 2013 to Feb 2014.

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Figs. 2–8. Infestation of *Maconellicoccus hirsutus* on cocoa plants. **2**. Adults, nymphs, and eggs; **3.** damage to cocoa shoots; **4.** developing sooty mold; **5**, **6.** Infested cocoa flowers; **7.** *M. hirsutus* infesting young cocoa fruit; **8.** *M. hirsutus* infesting mature cocoa fruit.

formation of shoots and atrophy of terminal buds, and reduction in new flushes of growth. Infested shoot tips had a bushy form leading to an appearance similar to "bunchy top," as described by Kairo et al. (2000) on *M. hirsutus* infested hibiscus. Flowers infested with *M. hirsutus* usually appeared wilted or dead. Fruits infested with *M. hirsutus* in early stages of development were deformed. Death of infested cocoa plants was not observed, but development of young plants appeared to be inhibited in comparison with nearby uninfested plants.

The predatory lady beetle *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) was found with occasional occurrence in *M. hirsutus* infested samples collected in this research, but no parasitoids were observed in the samples. Parasitoids of *M. hirsutus*, such as *Anagyrus kamali* Mourisi and *Gyranusoidea indica* Shafee, Alam & Agarwal (Hymenoptera: Encyrtidae) have successfully been used in other areas for classical biological control of *M. hirsutus*, but are not recorded in this region (Michaud 2003; Noyes 2016).

Results of this study confirm that *M. hirsutus* is now established and widespread on cocoa in Bahia and Espírito Santo, Brazil, the main cocoa producing region of South America. This pest now threatens cocoa and other crops in one of the major cocoa producing areas of the world, and the occurrence of *M. hirsutus* on cocoa reported in this study is an indication of its expanding range in Brazil and South America, where it also threatens native Neotropical biodiversity. These results indicate that further research should be conducted to evaluate the potential introduction of biological control agents for control of *M. hirsutus* in this region.

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Summary

Maconellicoccus hirsutus (Green) (Hemiptera: Pseudococcidae) was first detected in Brazil in 2010, and this study documents the recent range expansion into the major cocoa producing regions of Espírito Santo and Bahia, Brazil. We describe the signs of *M. hirsutus* infestation and damage to cocoa plants. Infestation of cocoa by adult females with nymphs and egg masses was observed, particularly on new flushes of growth and on fruits, and is a major threat to one of the largest cocoa producing areas of the world. The predator *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) was associated with *M. hirsutus*, but no parasitoids were observed. *Maconellicoccus hirsutus* is now established and widespread on cocoa in southeastern Brazil and spreading to producing regions of Bahia.

Key Words: geographic distribution; invasive species; range expansion; *Theobroma cacao*

Sumário

Maconellicoccus hirsutus (Green) (Hemiptera: Pseudococcidae) foi detectada pela primeira vez no Brasil em 2010, é praga invasora e potencial de muitas espécies de plantas e que se estabeleceu nas regiões tropicais e subtropicais. Este estudo documenta a recente expansão de *M. hirsutus* na maior região produtora de cacau do Brasil, é seu primeiro relato em cacau na América do Sul e documenta os sintomas de sua ocorrência em plantas infestadas de cacau. Foram observadas infestações de adultos com ninfas e massa de ovos, principalmente em novos pontos de crescimento e frutos, ela agora ameaça uma das principais áreas produtoras de cacau do mundo. O predador *Cryptola-*

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emus montrouzieri Mulsant (Coleoptera: Coccinellidae) foi associado a *M. hirsutus*, no entanto nenhum parasitoide emergiu das cochonilhas. *Maconellicoccus hirsutus* está estabelecida no Sudeste do Brasil e se dissemina nas regiões produtoras de cacau da Bahia.

Palavras Chave: encarquilhamento de brotações; espécie invasiva; planta hospedeira; *Theobroma cacao*

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