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Maconellicoccus hirsutus (Hemiptera: Pseudococcidae) in Brazil: recent spread, natural enemies, and new hosts

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Maconellicoccus hirsutus (Green) (Hemiptera: Pseudococcidae), the pink hibiscus mealybug, is an invasive pest from southern Asia or Australia that now has a worldwide distribution in tropical and subtropical regions (Sagarra & Peterkin 1999; Chong et al. 2008; Garcia Morales et al. 2016). In the Americas, this mealybug was first detected in 1993 on the island of Grenada (Michaud & Evans 2000). It was first noted in South America in Guyana (Tambasco et al. 2000), and it now also is present in Brazil, Colombia, French Guiana, Suriname, and Venezuela (Culik et al. 2013a, b; Garcia Morales et al. 2016). In Brazil, it was first detected in 2010 in the state of Roraima in northern Brazil, bordering Guyana and Venezuela (Marsaro Junior et al. 2013). By 2012, it had spread to the southern part of the state of Espírito Santo, in southeastern Brazil, about 3,400 km from Roraima (Culik et al. 2013a). Since 2010, *M. hirsutus* has spread to 9 other Brazilian states, including Pará (northern region) (Morais 2016; Peres-Filho et al. 2017); Alagoas, Bahia, Maranhão, and Pernambuco (northeastern region) (Silva et al. 2013a, b; Nakayama & Virgens Filho 2014; Oliveira et al. 2014; Souza et al. 2014; Broglio et al. 2015; Fornazier et al. 2017; Ramos et al. 2018); Mato Grosso (central-western region) (Morais et al. 2015; Peres-Filho et al. 2017); São Paulo (southeastern region) (Morais et al. 2015; Peronti et al. 2016); Rio Grande do Sul, and Santa Catarina (southern region) (Alexandre et al. 2014; Morais 2016). Based on these records, *M. hirsutus* was removed from the Brazilian List of Absent Quarantine Pests (A1) on 18 Dec 2013 (Brasil 2013). *Maconellicoccus hirsutus* is considered to be a quarantine pest, and may be a threat to agriculture in countries where it has been introduced because of its polyphagous behavior, invasiveness, and high reproductive potential (Cermeli et al. 2002; Martínez Rivero 2007). It has been reported from more than 350 species of host plants, in 222 genera and 78 botanical families, and may be a potential pest of many economically important crops, including fruits, fibers, grains, ornamental, and timber species (Garcia Morales et al. 2016).

This note summarizes recent research on the geographical spread, host plants, and natural enemies of *M. hirsutus* in Brazil since its reported establishment in this country 8 years ago (Marsaro Junior et al. 2013), and its dissemination and hosts in Espírito Santo State, southeastern Brazil, since it was first noted in this region in 2012 (Culik et al. 2013a). One hundred and three *M. hirsu-*

tus-infested host plant samples were collected and geo-referenced (longitude, latitude) from 34 municipalities of Espírito Santo by professionals of the State Inspection Service of Agricultural and Forest Defense Institute of Espírito Santo (Idaf), the Capixaba Institute for Research and Technical Assistance and Rural Extension (Incaper), and the Executive Committee for the Planning of Cacao Crops (Ceplac/ES). Mealybug specimens were preserved in Eppendorf tubes (5 mL) with 70% alcohol, and mounted on microscope slides (Gullan 1984), with identification of the species made based on morphological characteristics of the adult female (Miller 1999; Miller et al. 2014) at the Laboratory of Entomology, Universidade Estadual Paulista “Júlio de Mesquita Filho” (FCAV/UNESP). A map with isotherms and *M. hirsutus* sampling points in Espírito Santo was prepared using ESRI ARCGIS 10.0, Arcmap software (ESRI 2011) and the Meteorological Information System/Incaper climatological database (Incaper 2018).

In Espírito Santo, *M. hirsutus* was found only in regions with annual mean temperatures from 20 to 27 °C, with 96% of *M. hirsutus* samples found in the isotherm 23 to 27 °C (Fig. 1). This annual mean temperature range (20 to 27 °C) is found in 87.6% of the area of the state. These results are consistent with previous research which indicates that temperatures most favorable for the development and reproduction of *M. hirsutus* are 25 to 27 °C, and the thermal thresholds for female development are 14.5 °C (T_{min}) and 29 °C (T_{max}) (Chong et al. 2008). In Espírito Santo, only 0.2% of its territory has annual mean temperatures below 14.5 °C, and none with annual mean temperature above 27 °C (Fig. 1). Therefore, temperatures in Espírito Santo do not represent a barrier to *M. hirsutus* population development.

Seventeen species of *M. hirsutus* host plants in 9 families were collected in Espírito Santo (Table 1). *Hevea brasiliensis* (Euphorbiaceae), *Theobroma bicolor* and *T. speciosum* (Malvaceae) are reported for the first time as hosts of *M. hirsutus* (García Morales et al. 2016). *Coccoloba uvifera* (Polygonaceae), *Morus alba* (Moraceae), *Punica granatum* (Lythraceae), and *Talipariti tiliaceum* (Malvaceae) are new *M. hirsutus* host records for Brazil. *Abelmoschus esculentus* (L.) Moench (Malvaceae), *Theobroma cacao* L. (Malvaceae), and *Solanum americanum* Mill. (Solanaceae) have been reported previously as *M. hirsutus* hosts in Espírito Santo (Culik et al. 2013a;

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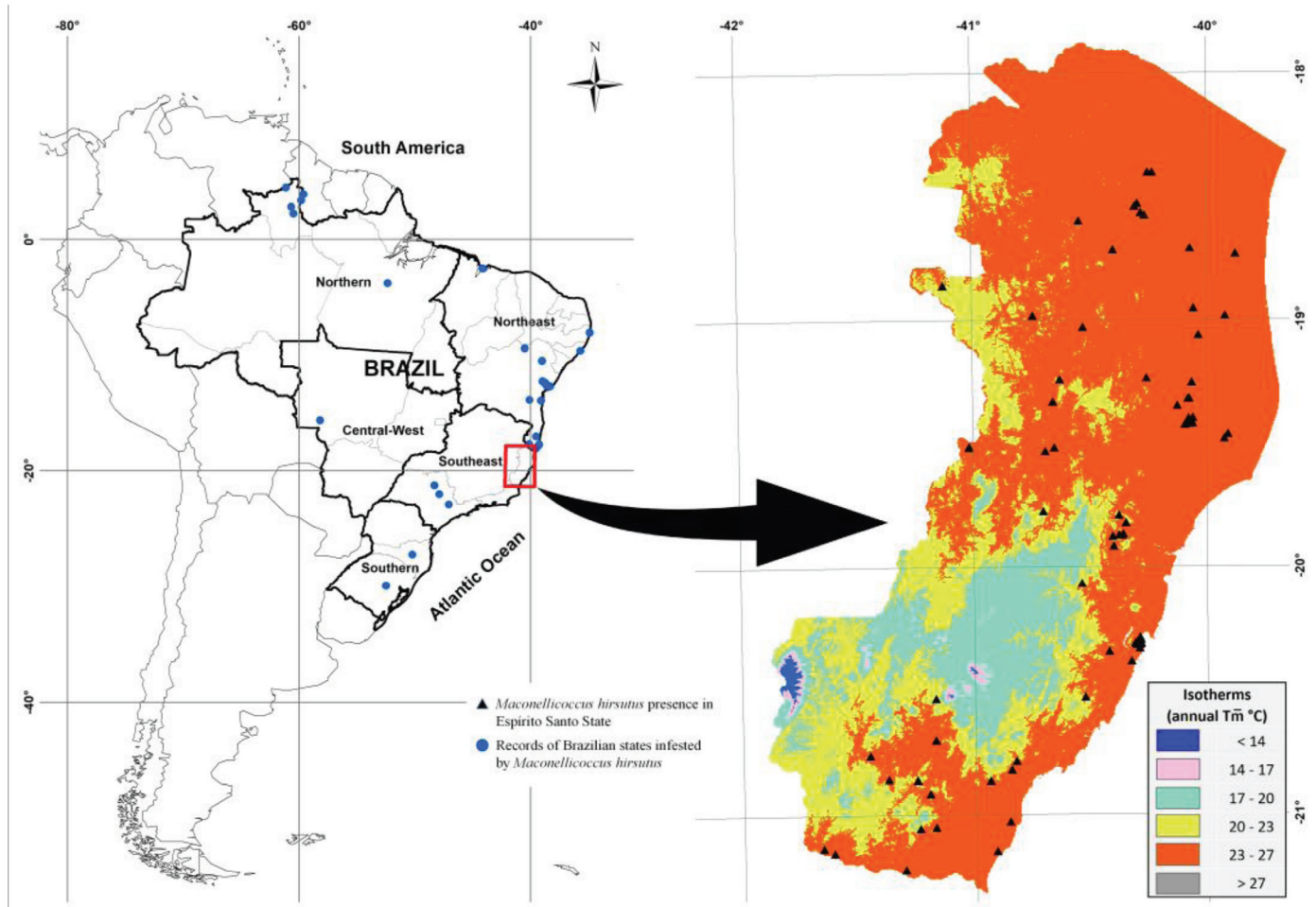


Fig. 1. Geographic distribution of *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) in Brazil, and *M. hirsutus* collection locations in the state of Espírito Santo, Brazil.

García Morales et al. 2016; Fornazier et al. 2017), and the other 13 host species found are new *M. hirsutus* records for this state (Table 1). Highest populations of *M. hirsutus* were found associated with apical buds of young plants, resulting in deformation of shoots, leaves, and fruits, and death of inflorescences. Deformation of shoots and atrophy of terminal buds associated with high infestations of this mealybug observed in this study are similar to damage by the pest described in other studies (Martínez Rivero 2007; Morais et al. 2015; Fornazier et al. 2017). Hibiscus ($n = 30$) and cocoa ($n = 30$) were the most common plants found infested by *M. hirsutus*, and ornamental hibiscus plants (*Hibiscus rosa-sinensis* L.; Malvaceae) may be the most important hosts for dissemination of this mealybug in Espírito Santo. *Talipariti tiliaceum* (L.) Fryxell (Malvaceae) ($n = 8$) (sea hibiscus) and *Coccoloba uvifera* (L.) Crantz (Polygonaceae) (seagrape) are other hosts that may be important species for *M. hirsutus* dissemination because of their use as ornamental plants. Currently *Talipariti* is composed of 22 taxa that are found from southeastern Asia to Central and South America. Sea hibiscus was previously described as a species of the genus *Hibiscus* (Malvaceae) (Fryxell 2001), and it occurs from the southern to northeastern Brazilian coast (Morais & Magenta 2014). Seagrape (*Coccoloba uvifera*) is widely grown on coastal beaches throughout tropical America and the Caribbean, including southern Florida, where it is also used as a seaside hedge in commercial landscapes (Gilman & Watson 2014).

Plant species from 19 families have been reported as hosts of *M. hirsutus* in Brazil, including those of economic importance, such as Malvaceae ($n = 7$) and Fabaceae ($n = 6$), which are the most important host plant families in Brazil based on number of host plant species (Table 1), although Moraceae and Euphorbiaceae have the highest number of *M. hirsutus* host species worldwide (García Morales et al. 2016). Thirty-seven plant species are now reported as hosts of *M. hirsutus* in Brazil.

Although *M. hirsutus* has a large number of natural enemies (Culik et al. 2013b; Garcia Morales et al. 2016), none were observed in the present study. In Brazil, *Anagyrus kamali* Moursi (Hymenoptera: Encyrtidae), and *Gyranoidea indica* Shafee, Alam & Agarwal (Hymenoptera: Encyrtidae) are reported as parasitoids of *M. hirsutus*, and *Chilocorus nigrita* (F.), *Cryptolaemus montrouzieri* Mulsant, *Cycloneda sanguinea* (L.), *Eriopis* (Germar), *Exoplectra* sp., *Harmonia axyridis* (Pallas), *Tenuisvalvae notata* (Mulsant) (all Coleoptera: Coccinellidae), and *Ceraeochrysa* sp. (Neuroptera: Chrysopidae) are listed as *M. hirsutus* predators (Culik et al. 2013a). *Anagyrus kamali* and *C. montrouzieri* have been the most common natural enemies associated with *M. hirsutus* in Brazil (Marsaro Junior et al. 2013; Peronti et al. 2016; Negrini et al. 2018). However, there have been no studies in Brazil to evaluate the establishment and efficiency of these natural enemies in agroecosystems where *M. hirsutus* has caused damage (Morais 2016).

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Table 1. *Macronelliococcus hirsutus* (Green) (Hemiptera: Pseudococcidae) host plants in Brazil including new records and references.

Family/host plants ¹	Brazilian states ² (municipalities)	References
Anacardiaceae		
<i>Mangifera indica</i> L.	AL (Maceió)	Broglio et al. (2015)
<i>Spondias lutea</i> L.	AL (Maceió)	Broglio et al. (2015)
<i>Spondias tuberosa</i> Arruda	MA (Paço do Lumiar, São José de Ribamar)	Ramos et al. (2018)
Annonaceae		
<i>Annona muricata</i> L.***	AL (Maceió), RR (Cantá, Normandia), ES (Colatina)	Marsaro Jr. et al. (2013), Broglio et al. (2015), Negrini et al. (2018), present study
<i>Annona squamosa</i> L.***	MA (Paço do Lumiar, São José de Ribamar), RR (Cantá), ES (Pinheiros, Vitória)	Negrini et al. (2018), Ramos et al. (2018), present study
Euphorbiaceae		
<i>Hevea brasiliensis</i> (Willd. ex A. Juss.) Müll. Arg.*	ES (Linhares)	present study
Fabaceae		
<i>Centrolobium paraense</i> Tul.	RR (Boa Vista)	Marsaro Jr. et al. (2013)
<i>Erythrina variegata</i> L.	PE (Recife)	Melo & Meunier (2017)
<i>Glycine max</i> (L.) Merr.	RR (Boa Vista)	Marsaro Jr. et al. (2013)
<i>Inga edulis</i> Mart.***	RR (Boa Vista), ES (Linhares)	Marsaro Jr. et al. (2013)
<i>Mimosa caesalpinifolia</i> Benth***	BA (Jequié, Semi arid region), PE (Semi arid region), ES (Linhares, Nova Venécia, São Mateus, Vila Pavão)	Oliveira et al. (2014), Marques et al. (2017), present study
<i>Mimosa tenuiflora</i> (Willd.) Poir.	BA and PE (Semi arid region of Brazil)	Oliveira et al. (2014)
Lamiaceae		
<i>Tectona grandis</i> L.f.	MT (São José de Quatro Marcos)	Peres-Filho et al. (2017)
Lythraceae		
<i>Punica granatum</i> L.**	ES (Viana)	present study
Malpighiaceae		
<i>Malpighia glabra</i> L.	AL (Maceió)	Broglio et al. (2015)
<i>Malpighia puniceifolia</i> L.	MA (Paço do Lumiar, São José de Ribamar)	Ramos et al. (2018)
Malvaceae		
<i>Abelmoschus esculentus</i> (L.) Moench	ES (Cachoeiro de Itapemirim)	Culik et al. (2013a), present study
<i>Hibiscus rosa-sinensis</i> L.***	BA (Camamu, Caravelas, Eunápolis, Jequié, Ibirapuá, Itamarajú, Mucuri, Nova Viçosa.), MT (<i>unidentified</i>), RR (Boa Vista, Bonfim, Pacaraima), SC (<i>unidentified</i>), SP (Campinas, Jabotocabal, São Carlos), ES (Aplacá, Atílio Vivacqua, Baixo Guandu, Boa Esperança, Bom Jesus do Norte, Castelo, Colatina, Iconha, Itapemirim, Jaguaré, Linhares, Mantenópolis, Marataízes, Mimoso do Sul, Muqui, Pinheiros, Rio Bananal, Rio Novo do Sul, Vila Velha, Vitória)	Marsaro Jr. et al. (2013), Silva et al. (2013b), Alexandre et al. (2014), Morais et al. (2015), Peronti et al. (2016), Marques et al. (2017), present study
<i>Talipariti tiliaceum</i> (L.) Fryxell**	ES (Vitória, Vila Velha)	present study
<i>Theobroma bicolor</i> Humb. & Bonpl.*	ES (Linhares)	present study
<i>Theobroma cacao</i> L.	BA (Amélia Rodrigues, Camaçari, Camamu, Candeias, Eunápolis, Feira de Santana, Itamarajú, Jequié, Mucuri, Santo Amaro, São Francisco do Conde), ES (Aguia Branca, Atílio Vivacqua, Colatina, Guarapari, Ibraçu, Jaguaré, João Neiva, Linhares, Nova Venécia, São Domingos do Norte, São Gabriel da Palha, São Mateus, Sooretama)	Silva et al. (2013b), Nakayama & Santos (2014), Fornazier et al. (2017), Marques et al. (2017), present study
<i>Theobroma grandiflorum</i> (Willd. ex Spreng.) Schum.***	AL (Maceió), MA (Paço do Lumiar, São José de Ribamar), ES (Linhares)	Broglio et al. (2015), Ramos et al. (2018), present study
<i>Theobroma speciosum</i> Willd. ex Spreng.*	ES (Linhares)	present study

¹Names according to the Catalogue of Life (2018); ²Brazilian states: AL (Alagoas), BA (Bahia), ES (Espírito Santo), MA (Maranhão), MT (Mato Grosso), PE (Pernambuco), RR (Roraima), SC (Santa Catarina), SP (São Paulo); *new host record for *M. hirsutus* (according to García Morales et al. 2016); **new host record for *M. hirsutus* in Brazil; ***new host record for *M. hirsutus* in Espírito Santo, Brazil.

Table 1. (Continued) *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) host plants in Brazil including new records and references.

Family/host plants ¹	Brazilian states ² (municipalities)	References
Moraceae <i>Morus alba</i> L.**	ES (Linhares)	present study
Myrtaceae <i>Psidium guajava</i> L.	AL (Maceió), RR (Normandia)	Marsaro Jr. et al. (2013), Broglio et al. (2015)
Oxalidaceae <i>Averrhoa carambola</i> L.	AL (Maceió), RR (Cantá, Normandia)	Marsaro Jr. et al. (2013), Broglio et al. (2015), Negrini et al. (2018)
Polygonaceae <i>Coccoloba uvifera</i> (L.) L.**	ES (Vitória)	present study
Proteaceae <i>Grevillea robusta</i> A. Cunn. ex R. Br.	BA and PE (Semi arid region of Brazil)	Oliveira et al. (2014)
Rosaceae <i>Pyrus</i> sp.	BA and PE (Semi arid region of Brazil)	Oliveira et al. (2014)
Rubiaceae <i>Coffea canephora</i> Pierre ex A. Froehner	BA (Mucuri)	Silva et al. (2013b)
<i>Ixora chinensis</i> Lam. (syn. <i>Ixora coccinea</i> Curtis)	BA (Metropolitan region official Salvador)	Silva et al. (2013a)
<i>Mussaenda erythrophylla</i> Schumacher & Thonn	BA (Metropolitan official region of Salvador)	Silva et al. (2013a)
Rutaceae <i>Citrus sinensis</i> (L.) Osbeck***	RR (Normandia), ES (Alegre, Jerônimo Monteiro, João Neiva)	Marsaro Jr. et al. (2013), present study
Solanaceae <i>Solanum lycopersicum</i> L.	RR (Boa Vista)	Marsaro Jr. et al. (2013)
<i>Solanum americanum</i> Mill.	ES (Cachoeiro de Itapemirim)	Culik et al. (2013a), present study
Talinaceae <i>Talinum paniculatum</i> (Jacq.) Gaertn.	BA and PE (Semi arid region of Brazil)	Oliveira et al. (2014)
Vitaceae <i>Vitis vinifera</i> L.	BA and PE (Semi arid region of Brazil)	Oliveira et al. (2014)

¹Names according to the Catalogue of Life (2018); ²Brazilian states: AL (Alagoas), BA (Bahia), ES (Espírito Santo), MA (Maranhão), MT (Mato Grosso), PE (Pernambuco), RR (Roraima), SC (Santa Catarina), SP (São Paulo); ³*new host record for *M. hirsutus* (according to Garcia Morales et al. 2016); ⁴**new host record for *M. hirsutus* in Brazil; ⁵***new host record for *M. hirsutus* in Espírito Santo, Brazil.

Summary

Maconellicoccus hirsutus (Green) (Hemiptera: Pseudococcidae) is an invasive and highly polyphagous pest with a worldwide distribution in tropical and subtropical regions. This study reports the geographical distribution, natural enemies, and host plant species of *M. hirsutus* in Brazil 8 years after its first report in this country. *Maconellicoccus hirsutus* is now distributed in 11 Brazilian states, in all major geographic regions of the country. Samples (n = 103) of plants infested by *M. hirsutus* were collected in the state of Espírito Santo, Brazil, with 96% of them found within the isotherm 23 to 27 °C. *Hevea brasiliensis* (Euphorbiaceae), *Theobroma bicolor* (Malvaceae), and *T. speciosum* (Malvaceae) are reported for the first time as hosts of *M. hirsutus*, and *Coccoloba uvifera* (Polygonaceae), *Morus alba* (Moraceae), *Punica granatum* (Lythraceae), and *Talipariti tiliaceum* (Malvaceae) are new hosts of *M. hirsutus* in Brazil. Thirty-seven host plant species of *M. hirsutus* are now confirmed in Brazil.

Key Words: geographical spread; *Hevea brasiliensis*; pink hibiscus mealybug; *Theobroma bicolor*; *Theobroma speciosum*

Sumario

Maconellicoccus hirsutus (Green) (Hemiptera: Pseudococcidae) é praga invasora e altamente polífaga distribuída nas regiões tropicais e subtropicais do mundo. Este estudo relata a distribuição geográfica, inimigos naturais e espécies de plantas hospedeiras de *M. hirsutus* no Brasil após oito anos de seu primeiro relato. *Maconellicoccus hirsutus* se encontra distribuída em onze estados em todas as regiões geográficas do Brasil. Foram coletadas 103 amostras de plantas infestadas com *M. hirsutus* no estado do Espírito Santo com 96% delas encontradas na isoterma 23 to 27 °C. *Hevea brasiliensis* (Euphorbiaceae), *Theobroma bicolor* (Malvaceae), e *T. speciosum* (Malvaceae) são relatadas pela primeira vez como hospedeiras de *M. hirsutus*, e *Coccoloba uvifera* (Polygonaceae), *Morus alba* (Moraceae), *Punica granatum* (Lythraceae), e *Talipariti tiliaceum* (Malvaceae) são novas constatações para o Brasil. Trinta e sete plantas hospedeiras de *M. hirsutus* são agora relatadas no Brasil.

Palavras Chave: cochonilha-rosada-do-hibisco; dispersão geográfica; *Hevea brasiliensis*; *Theobroma bicolor*; *Theobroma speciosum*

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