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WHITEFLIES (HEMIPTERA: ALEYRODIDAE) ASSOCIATED WITH PAPAYA (*Carica papaya* L.)

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ABSTRACT- Whiteflies are worldwide one of the most important agricultural pests. They have a broad geographical distribution and feed on agricultural important crops, forest, ornamental and native plants. They may cause direct damage to plants by sucking sap, injection of toxins and may cause decrease in growth and yield. Indirect damages may be associated with virus transmission and they make possible the development of fungi, such as sooty mold in the surface of leaves. They may be considered as secondary pests of papaya, but high infestations have frequently been observed in mainly areas of Brazilian papaya crops. This study aimed to identify whiteflies species that occur in papaya in Brazil, as well as report the world species related in this culture. Infested leaves were collected in commercial crops under field conditions, herborized with paper sheets and dried in the shade. Morphological characters of 4th instar nymphs were used to identification of the species in the Department of Entomology and Plant Pathology, Institute of Biological Sciences and Health, Rural Federal University of Rio de Janeiro. Nineteen samples were collected in the States of Espírito Santo and Rio de Janeiro, and all of the specimens were identified as *Trialeurodes variabilis* (Quaintance). Nine species of whiteflies are reported worldwide associated with papaya, and two have already been registered in Brazil. *Trialeurodes variabilis* is the most important species of whitefly for papaya in Brazil.
KEYWORDS: Aleyrodidae. *Carica papaya*. Papaya. *Trialeurodes variabilis*. Whiteflies.

RESUMO- Moscas-brancas são uma das mais importantes pragas agrícolas no mundo. Apresentam ampla distribuição geográfica e se alimentam em plantas de importância agrícola, florestal, ornamental e silvestres. Causam danos diretos nas plantas pela sucção de seiva, anomalias pela injeção de toxinas e provocam redução no crescimento e produtividade. Danos indiretos podem ser associados à transmissão de viroses e pelo desenvolvimento de fungos, como fumagina na superfície das folhas. São consideradas pragas secundárias do mamoeiro, mas altas infestações têm sido observadas com frequência nas principais áreas de cultivos de mamão no Brasil. Este trabalho teve como objetivo identificar as espécies de moscas-brancas que ocorrem no mamoeiro no Brasil, bem como reportar as registradas nesta cultura no mundo. Folhas infestadas com moscas-brancas foram coletadas em lavouras comerciais, herborizadas entre folhas de papel e secas à sombra. A identificação das espécies foi feita no Departamento de Entomologia e Fitopatologia do Instituto de Ciências Biológicas e da Saúde, da Universidade Federal Rural do Rio de Janeiro, com base nos caracteres morfológicos das ninfas de 4º instar. Dezenove amostras foram coletadas no estado do Espírito Santo e Rio de Janeiro e identificadas como *Trialeurodes variabilis* (Quaintance). Nove espécies de moscas-brancas são relatadas associadas ao mamoeiro no mundo e duas destas ocorrem no Brasil. *Trialeurodes variabilis* é a mais importante espécie de mosca-branca para o mamoeiro no Brasil.
PALAVRAS-CHAVE: Aleyrodidae. *Carica papaya*. Mamoeiro. Moscas-brancas. *Trialeurodes variabilis*.

1 INTRODUCTION

Aleyrodidae insects are usually known as whiteflies, belong to the Hemiptera's order, suborder Sternorrhyncha, and may be considered as one of the most important agricultural pests around the world. This group includes many pest species that have broad geographic distribution and feed in many agricultural important crops, forest, ornamental and native plants (EVANS, 2007).

These insect species may cause directly damage to plants by sucking sap from the vascular tissue of leaves, extracting carbohydrates and amino acids. It may cause anomalies or phytotoxic disorders by the injection of toxins during the feeding process, and thereby weakening occurs and reduction in growth rate and yield (BERLINGER, 1986). These whiteflies may cause indirect damages to plants by the transmission of viruses. Furthermore, opportunistic fungi such as sooty mold may develop in the honeydew of these insects, and it may affect photosynthesis and may depreciate the fruits (LOURENÇÃO et al., 2015). Yellowing in leaves may be observed as a result of a severe attack, in addition to reduction in size, and soluble solids content of fruits (PICANÇO et al., 2003).

Whiteflies may currently transmit several begomovirus to more than 20 economic important crops, including papaya (*Carica papaya* L.) (CULIK et al., 2003; ANDERSON et al., 2005; AARON et al., 2012). Despite of papaya be a related host plant of whiteflies species, colonies of this insect in the canopy of papaya plants have sporadically been observed (REZENDE et al., 1981). However, high infestations of whiteflies may be found in isolated areas of papaya cultivation (CULIK et al., 2003 and 2004). Infestation of whitefly may vary among varieties and genotypes of papaya and according to the position of the leave in the canopy (FANCELLI et al., 2004 and 2006).

Nine species of whiteflies have been worldwide reported causing damage to papaya, and *Bemisia tabaci* (Gennadius, 1889) biotype B and *Trialeurodes variabilis* (Quaintance, 1900) were recorded as potential pests of papaya in Brazil (VIEIRA and CORREIA, 2001; CULIK et al., 2003; CULIK and MARTINS, 2004; FANCELLI et al., 2004 and 2006; VIDAL et al., 2005). This study aimed to identify the whiteflies species that occur in the main Brazilian papaya production region, and report those recorded in this crop in production areas of the world.

2 MATERIAL AND METHODS

Samples (n=326) were carried out to identify the association of insects with papaya under field conditions from 2002 to 2014 in the main Brazilian commercial papaya production-region in northern Espírito Santo State, in the municipalities of Linhares, and Sooretama. Additional samples were performed on single plants at domestic cultivation in the municipalities of Vitória, Espírito Santo State, and Itaguaí, Nova Iguaçu, Rio de Janeiro, and Seropédica, Rio de Janeiro State.

Leaves with immature stages of the whiteflies were herborized with paper sheets, dried in shade, and sent for species identification in the Department of Entomology and Plant Pathology, Institute of Biological Sciences and Health, Rural Federal University of Rio de Janeiro (UFRRJ).

Identification was based on morphological characters of the 4th instar nymphs ("pupae"), which were taken from the leaf blade using entomological pin, and mounted with Canada

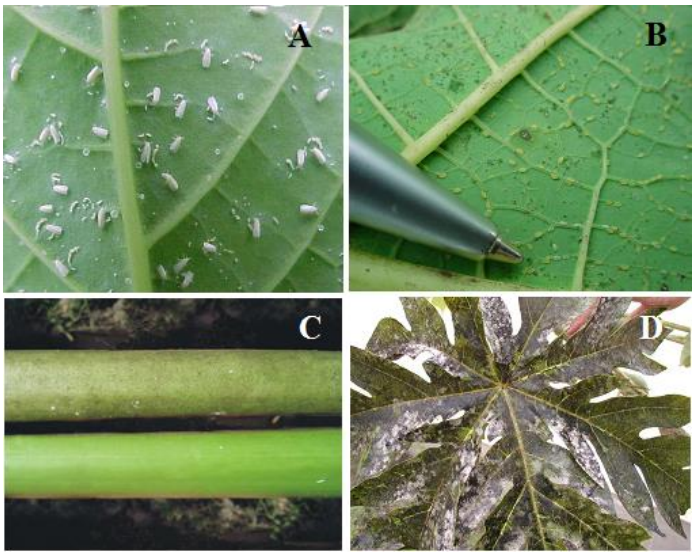
balsam. The slides were properly labeled with information regarding to the location, date, and name of the collector (BAKER and WHARTON, 1952).

Voucher specimens were deposited in the Entomological Collection Ângelo Moreira da Costa Lima (CECL), Institute of Biological Sciences and Health, Rural Federal University of Rio de Janeiro.

3 RESULTS AND DISCUSSION

Nineteen samples of papaya leaves were identified as infested with whiteflies in Linhares (n=10), Sooretama (n=2), and Vitória (n=3), Espírito Santo State, and in the municipalities of Itaguaí (n=1), Nova Iguaçu (n=1), Seropédica (n=1), and Rio de Janeiro (n=1), Rio de Janeiro State. All of the specimens collected in the 19 samples were identified as *T. variabilis*. This species was observed in high infestations in the sampled rural and urban areas with presence of adults and nymphs, besides the occurrence of the sooty mold on the petioles and leaves of papaya (Figure 1).

FIGURE 1: Adults (A) and nymphs (B) of *Trialeurodes variabilis* (Quaintance, 1900); infested petiole (C) and leaf (D) of papaya associated with sooty mold (C, D)



Nine species of whiteflies have been worldwide reported associated with papaya (Table 1): *Aleurocanthus woglumi* Ashby, *Aleuroctarthrus destructor* (Mackie), *Aleurodicus dispersus* Russell, *Aleurodicus floccissimus* (Martin, Hernandez-Suarez & Carneiro) (= *Lecanoideus floccissimus* Martin, Hernandez-Suarez & Carneiro), *Bemisia tabaci* (Gennadius), *Tetraleurodes acaciae* (Quaintance), *Trialeurodes floridensis* (Quaintance), *Trialeurodes vaporariorum* (Westwood) e *Trialeurodes variabilis* (Quaintance) (PANTOJA et al., 2002; CULIK et al., 2003; EVANS, 2007; MARTIN, 2008).

Initial infestation of *T. variabilis* occurred under field conditions in developing leaves on the top of the canopies, and in limited areas of papaya crops; thus, insects moved to the newly developed leaves where a great number of nymphs could be observed. Population structure of *T. variabilis* varied with the age of the plant leaf with insect preference for feeding and oviposition in younger leaves when compared to fully developed one. Eggs and nymphs

were found in higher number on the apical and median canopy, and on new leaves. Older leaves showed oviposition concentrated in the basal region, and nymphs were more frequently in the median region (FANCELLI et al., 2004 and 2006).

Trialeurodes variabilis is widely distributed in the Americas, from the United States to Brazil, and reported as a major pest of cassava (*Manihot esculenta* Crantz) in the Neotropics (BELLOTTI and ARIAS, 2001), and papaya in Florida, USA (CULIK et al., 2003), Guatemala, West Indies, and Caribbean (PANTOJA et al., 2002). In addition, other *Tr. variabilis* hosts have been related, such as Aceraceae [*Acer mexicanum* (de Candolle) Pax]; Euphorbiaceae [*Manihot glaziovii* Müll. Arg. (= *M. carthaginensis* subsp. *Glaziovii* (Müll. Arg.) Allem]; Polygonaceae [*Coccoloba floribunda* (Benth.) Lindau]; Rubiaceae [*Gardenia* sp.]; and Rutaceae [*Citrus paradise* Macfad, *C. reticulate* Blanco] (MOUND and HALSEY, 1978). This species is more dispersed than *B. tabaci* biotype B in Brazilian papaya production-regions, and its occurrence has been recorded in the States of Bahia, Espírito Santo, Pernambuco and São Paulo (REZENDE et al., 1981 CULIK and MARTINS, 2004 FANCELLI et al., 2004).

Records of *Trialeurodes* spp. have been found in papaya in the Brazilian States of Bahia, Mato Grosso do Sul, and Pernambuco (VIEIRA and CORREA, 2001; VIDAL et al., 2005). Although *T. variabilis* has been detected in several papaya producing-regions in Brazil, this species has not been recognized as an important pest of papaya or other fruit in this country (PICANÇO et al., 2003). This was also observed in 90% of papaya producing areas of northern Espírito Santo where less than 8% of farmers had included whiteflies among the three most important pest species for this crop (MARTINS et al., 2003).

Although sporadic, the occurrence of whiteflies on papaya has been observed frequently in northern Espírito Santo in periods of higher temperature and rainfall, mainly from January to March; this is one of the most important Brazilian papaya producing and exporting-region (MARTINS, 2003; COUTO et al., 2003).

Bemisia tabaci (biotype B) is an insect species that was already registered on papaya in Brazil, and it was not observed in these sampled regions. Its occurrence on Brazilian papaya is limited to protected environments where this plant has been cropped. This is a cosmopolitan species with wide geographical distribution, and it occurs in five continents, particularly in tropical and subtropical regions. It has about 600 species of host plants distributed in at least 63 plant families, mainly Compositae, Euphorbiaceae, Leguminaseae, Malvaceae, and Solanaceae (EVANS, 2007; LOURENÇÃO et al., 2015). Its occurrence on papaya is reported in Bangladesh (Chapai), Costa Rica, Honduras, India (Jodhpur - Rajasthan, Uttar - Pradesh), and USA (Hawaii) (BRUNT et al., 2015; RAMIREZ and ZÚÑIGA, 2003; MARUTHI et al., 2007, SENANAYAKE et al., 2012; DUBEY et al., 2015). *Bemisia tabaci* has been reported in Brazil only in environmental protected growing areas in the States of Bahia, and Mato Grosso do Sul (VIEIRA and CORREA, 2001; VIEIRA et al., 2004; VIDAL et al., 2005).

Table 1: Worldwide distribution of whiteflies (Hemiptera: Aleyrodidae) associated with papaya (*Carica papaya* L.)

Whitefly species	Geographic distribution	References
Aleurocanthus woglumi Ashby, 1915[1]	Central and South America	Evans (2007), Silva et al. (2011)
Aleuroctarthrus destructor (Mackie, 1912)[1]	Brazil, Pacific region	Pantoja et al. (2002), Evans (2007), Martin (2008)
Aleurodicus dispersus Russell, 1965[1]	Australia, Brazil, Cuba, India (Trissur, Kerala), Caribe, USA (Hawaii)	Picanço et al. (2003), Evans (2007), Boopathi et al. (2014)
Aleurodicus floccissimus (Martin, Hernandez-Suarez & Carnero, 1997)	Ecuador, Canary Islands	Culik et al. (2003), Evans (2007), Martin (2008)
Bemisia tabaci (Gennadius, 1889)[1]	Bangladesh (Chapai), Costa Rica, Honduras, India (Jodhpur - Rajasthan; Uttar - Pradesh)	Brunt et al. (1915), Ramírez and Zúñiga (2003), Maruthi et al. (2007), Senanayake et al. (2012), Dubey et al. (2015)
Bemisia tabaci (Gennadius, 1889) biótipo B[2]	USA (Hawai), Brazil (BA - Cruz das Almas; MS - Serviria)	Vieira and Correa (2001), Vieira et al. (2004), Vidal et al. (2005)
Tetraleurodes acaciae (Quaintance, 1900)	Mexico, USA (California)	Pantoja et al. (2002)
Trialeurodes floridensis (Quaintance, 1900)[1]	Central America, Neartic region	Evans (2007)
Trialeurodes vaporariorum (Westwood, 1856)[1]	Portugal (Madeira Island)	Aguiar and Pita (1995)
Trialeurodes variabilis (Quaintance, 1900)[2]	Cuba, Guatemala, USA (Miami, Florida), Trinidad, Brazil (BA - Cruz das Almas; ES - Linhares and Sooretama; PE - Petrolina)	Lamberts and Crane (2015), Culik et al. 2003, Picanço et al. (2003), Culik and Martins (2004), Fancelli et al. (2004), Evans (2007)

[1]Occurrence in Brazil, but not on papaya; [2]Occurrence in Brazil, and on papaya.

Papaya sticky disease or 'meleira' is one of the most important papaya diseases in Brazil, and it is caused by double infection of the papaya meleira virus (PMeV1 and PMeV2); however, its vector is hitherto not confirmed (VENTURA; COSTA; TATAGIBA, 2004). Association between papaya sticky disease virus and *B. tabaci* biotype B were reported (VIDAL; NASCIMENTO; HABIBE, 2005); no association have been found of these virus transmission with *T. variabilis* under experimental conditions in greenhouse or commercial production areas, even in high infestations levels of this insect (ANDRADE et al., 2003; LIMA et al., 2003; Rodrigues et al., 2009).

4 CONCLUSION

Trialeurodes variabilis is the most important species of whitefly associated with papaya in Brasil. *Bemisia tabaci* biotype B, despite being reported causing damage to papaya orchards in many biogeographic regions of the world, hitherto has limited occurrence in Brazil, mainly under protected environments.

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