

First record of the association of banana (*Musa* sp.) and *Ceratitis capitata* (Wiedemann, 1824) in Brazil

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Abstract - Brazil is the fourth world's largest banana (*Musa* spp.) producer and largest consumer. Mediterranean fruit fly *Ceratitis capitata* (Wiedemann, 1824) (Diptera: Tephritidae) is the main pest of quarantine importance in the exploration of fresh fruits. This species has shown wide ecological plasticity, with adaptation in several native and exotic hosts and different edaphoclimatic conditions. In November 2017 and March 2018, banana samples of AAB subgroup, Prata Anã, Prata Pacovan and Prata BRS Princesa, were collected from orchards located in the fruit producing region of São Francisco, Juazeiro, Bahia, Brazil. Fruits were sent to the laboratory for processing aimed at obtaining adults. A total of 177 tephritid pupae were obtained in Prata Anã variety, emerging 106 *C. capitata* adults. The total infestation rates in puparia kg fruit⁻¹ and puparia fruit⁻¹ were 7.45 and 0.70, respectively. Thus, the association between banana and *C. capitata* was recorded for the first time in Brazil and the probable implications related to this bitrophic association will be discussed.

Index terms: bitrophic interaction, Mediterranean fruit fly, quarantine pest, Prata Anã.

Primeiro registro da associação de banana (*Musa* sp.) e *Ceratitis capitata* (Wiedemann, 1824) no Brasil

Resumo - O Brasil é o quarto maior produtor e maior consumidor mundial de banana (*Musa* spp.). A mosca-do-Mediterrâneo *Ceratitis capitata* (Wiedemann, 1824) (Díptera: Tephritidae) se configura-se como a principal praga de importância quarentenária quando se visa à exportação de frutas *in natura*. Esta espécie vem demonstrando larga plasticidade ecológica, com adaptação em diversos hospedeiros nativos e exóticos, e diferentes condições edafoclimáticas. Em novembro de 2017 e março de 2018, amostras de banana do subgrupo AAB, variedades Prata-Anã, Prata-Pacovan e Prata-BRS-Princesa, foram coletadas em pomares do polo de fruticultura do Submédio São Francisco, Juazeiro, Bahia, Brasil. Os frutos foram encaminhados ao laboratório para processamento, visando à obtenção de adultos. Foram obtidos 177 pupários de tefritídeos na variedade Prata-Anã, emergindo 106 adultos de *C. capitata*. Os índices totais de infestação em pupários/kg de fruto⁻¹ e pupários/fruto⁻¹ foram de 7,45 e 0,70, respectivamente. Assim, registra-se, pela primeira vez no Brasil, a associação entre banana e *C. capitata*, e as prováveis implicações relacionadas a essa associação bitrófica são discutidas.

Termos para indexação: interação bitrófica, mosca-do-Mediterrâneo, praga quarentenária, Prata- Anã.

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Received: August 03, 2018
Accepted: October 30, 2018

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Brazil stands out as the fourth world's largest banana producer and largest consumer, with production of approximately 7 million tons in 2017, representing 6% of the world production (DOSSA; FUCHS, 2017). Bahia is the second largest banana producer state, with production of 802,000 tons in 2018, occupying an area of 84,000 ha (LSPA, 2018).

Several phytosanitary problems can lead to banana production and post-harvest losses, represented by some species of insects and mites, and mainly by phytopathogenic microorganisms (LICHTERBERG; LICHTERBERG, 2011). Unlike many other economically important fruit species, fruit flies (Diptera: Tephritidae) are not currently considered as insects with potential to reach banana crop pest status or to present quarantine importance when it comes to banana exports. However, the concern about the possible quarantine importance of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann, 1824) on banana exports is not recent. According to Back and Pemberton (1916), bananas (*Musa cavendishii* L.) produced in the Hawaiian Islands for export were monitored for a period of three years at the beginning of the 20th century, and no fruit infestation was observed. Fruits of other varieties "Brazilian" *Musa acuminata* (Hybrid AAB), "Valery" (=Taiwan) *M. acuminata* (AAA Robusta) and "William's" *M. acuminata* (AAA 'Giant Cavendish') were not confirmed as natural *C. capitata* hosts in Hawaii (ARMSTRONG, 1983). In Hawaii, Krainacker et al. (1987) confirmed the development of *C. capitata* in thirty hosts under laboratory conditions, including banana (*M. acuminata*). In Brazil, Raga et al. (2011) observed four Tephritoidea puparia in banana samples (*Musa paradisiaca* L.), variety Prata, collected in São Paulo, but all of them non-viable, preventing identification of associated fly species.

Since its introduction in Brazil in 1901, *C. capitata* has expanded its geographic distribution and adapted to the most diverse host fruits and edaphoclimatic conditions, reinforcing its characteristic of generalist and of high ecological plasticity. Current data reveal that 96 plant species have already been registered as *C. capitata* hosts (ZUCCHI; MORAES, 2012). Several records of new *C. capitata* hosts are recent, such as the cactaceae *Pereskia bahiensis* Gürke, and forage palm, *Opuntia ficus indica* (L.) Mill, in Bahia (LEITE et al., 2017).

Considering the importance of banana farming in Bahia and Brazil, as well as the possibilities of expanding the export of fresh fruits, it was hypothesized that banana fruits are hosts of fruit flies and, therefore, contribute to the maintenance of tephritid populations in fruit growing regions, being able to assume pest status. The aim of the present work was to increase the knowledge about interactions between fruit flies and their hosts, with an emphasis on banana, aiming at the management of these insects.

The selection of sampling points was performed adapting the concept of landscape epidemiology (BERGAMIN FILHO et al., 2016) for fruit flies. This concept considers factors that contribute to the spatial dispersion of organisms, particularly landscape characteristics that increase the risk of occurrence of a particular pest. Thus, fruit sampling were carried out in nine properties of fruit growing regions of the Submédio São Francisco valley, inserted in the irrigation projects of Salitre, Maniçoba and Mandacaru, in the municipality of Juazeiro, Bahia, Brazil. Properties were composed of banana (*Musa* sp.) plantations close to acerola (*Malpighia emarginata* DC), guava (*Psidium guajava* L.), mango (*Mangifera indica* L.) and papaya (*Carica papaya* L.) orchards or consortia of banana with guava or mango (Table 1). Ten samplings were carried out, one in November 2017 and the other in March 2018, with 1.5 to 4.0 kg of banana fruits being collected from each orchard at the maturation scales of Von Loesecke: 3 (more green than yellow), 5 (yellow with green tip) and 6 (yellow) (PBMH; PIF, 2006), according to the availability. Fruits were duly identified, including the cultivar, date of collection and geographical coordinates (Table 1), packed in plastic trays and transported to the Laboratory of Fruit Flies - State University of Southwestern Bahia, UESB, Vitória da Conquista, BA. In the laboratory, samples were counted and their mass was determined. Then, fruits were packed in plastic trays containing vermiculite to obtain larvae and / or puparia of fruit flies. Trays remained covered with voile fabric to avoid contamination and after 15 days, they were searched for the location of puparia, which were transferred to plastic containers containing vermiculite for the emergence of fruit fly adults. Infestation rates in puparia kg fruit⁻¹ and puparia fruit⁻¹ were calculated (Table 1).

A total of 251 banana fruits were collected, with total mass of 23,765.4 g. Fruit fly infestation was confirmed in banana variety Prata Anã (*Musa* sp.) at maturation scale 5 from Lots 286 from Santa Clara farm (collected in November 2017) and 301 from Salitre lot, obtaining 172 and 5 puparia, respectively, totaling 177 puparia. Of these, 106 *C. capitata* adults emerged, with total pupal viability of 59.89%, varying from 59.30% (Santa Clara) to 80.0% (Salitre). The highest infestation rates occurred in fruits from Santa Clara farm, reaching 146.08 puparia kg of fruit⁻¹ and 9.56 puparia fruit⁻¹ (Table 1).

Table 1. Sampling location of banana fruits (*Musa* sp.) as a function of the landscape, total area and banana (ha), fruit variety and maturation, geographical coordinates, number (n°) and mass (g) of fruits, puparia and emerged *Ceratitis capitata* adults (EA) (n°), pupal viability (PV) (%) and infestation rates (puparia kg fruit⁻¹ and puparia fruit⁻¹). Juazeiro, Bahia, Brazil, 2018.

Site	Landscape **	Área (ha)		Variety/ Maturation***	Geographic Coordinates	Fruit		Puparia		Infestation Rates		
		**	Total			Landscapes	Banana	(n°)	(g)	(n°)	EA	PV
Lot 286 Santa Clara farm*	Banana x Mango	147.2	27	Prata Anã/ 5	09°14' 54" S 40°15' 10" W	18	1,177.4	172	102	59.30	146.08	9.56
Lot 75 Salitre	Acerola and Guava	6.0	6	Prata Anã/ 3	09°32' 25" S 40°36' 56" W	24	2,447.0	0	0	-	-	-
Lot 32 Maniçoba	Banana x Mango	0.1	6	Prata BRS Princesa/ 5	09°19' 06" S 40°17' 48" W	22	1,661.0	0	0	-	-	-
Lot 302 Salitre	Guava	7.0	7	Prata Anã/ 5	09°35' 33,7" S 40°35' 27" W	28	3,101.0	0	0	-	-	-
Lot 279 Salitre	Banana x Guava	7.0	7	Prata Anã/ 5	09°35' 05" S 40°35' 57" W	34	3,890.0	0	0	-	-	-
Lot 136 Salitre	Banana	7.0	7	Prata Anã/ 5	09°34' 17" S 40°37' 53" W	23	1,823.0	0	0	-	-	-
Lot 301 Salitre	Mango and Guava	6.0	6	Prata Anã/ 5	09°34' 31" S 40°36' 15" W	24	1,636.0	5	4	80.00	3.06	0.17
Lot 286 Santa Clara farm	Banana x Mango	147.2	27	Prata Anã/ 5	09°14' 54" S 40°15' 10" W	36	3,405.0	0	0	-	-	-
Lot 29 Mandacaru	Mango and Guava	4.0	4	Prata Pacovan/ 5	09°23' 48" S 40°24' 14" W	4	829.0	0	0	-	-	-
Lot 78 Salitre	Acerola	6.0	6	Prata Anã/ 6	9°32' 26" S 40°37' 9.1" W	38	3,796.0	0	0	-	-	-
TOTAL	-	-	-	-	-	251	23,765.4	177	106	59.89	7.45	0.70

* Samples were collected in November 2017. The other samples were collected in March 2018. ** Data in column indicate banana cultivations in Consortia (Banana x Mango, Banana x Guava) or close to other fruit trees (Acerola, Guava and Mango). Maturation: 3 - more green than yellow, 5 - yellow with green tip and 6 - yellow (PBMW; PIF, 2006).

Data confirm the hypothesis that banana fruits with predominantly yellow coloration (yellow with green tip - scale 5) can act as *C. capitata* hosts. Banana is harvested before reaching scale 5; however, the inadequate harvest management, considered the most delicate operation of the fruit production activity, can result in the permanence of fruits of different ages in orchards and, therefore, of different maturation stages. The maintenance of fruits at maturation scales 5 (yellow with green tip), 6 (yellow) and 7 (yellow with brown areas), i.e., those that have exceeded the harvesting point, should be avoided in order to reduce the risks of maintenance of *C. capitata* populations in the orchard. The infestation symptoms of banana at maturation scale 5 were characterized by blackened spots in puncture sites. However, little is known about the fruit maturation stage preferred for oviposition and that at the same time allows the larval development of flies for the main cultivars planted in Brazil. According to Armstrong (1983), based on works conducted in Hawaii, USA, more mature bananas (stages 3 to 6) of the “Brazilian”, “Valery” and “William’s” varieties are preferred for oviposition by *C. capitata*, with no infestation occurring at initial stages (1 and 2), considered green. Suberization of the bark at the puncture site and the release of latex around the eggs were pointed out by the author as the main causes of egg infeasibility and mortality of first-instar larvae. No similar data for varieties cultivated in Brazil were found in the available literature.

In Bahia, there are currently 12 banana production regions, with total of 2,836 Production Units (PUs), distributed in all regions of the state, and Nanica (AAA), Prata (AAB), Terra (AAB) and Maçã (AAB) cultivars stand out as the most important (ADAB, 2018). There is a need to expand larval monitoring to other banana production regions and units, covering different varieties, soil and climatic conditions and associated landscapes.

Data corroborate recent studies on the great capacity of *C. capitata* adaptation to the most varied native and exotic hosts (ARAÚJO et al., 2016; CUSTÓDIO et al., 2016; LEITE et al., 2017; NEUTZLING et al., 2016). This species is classified as a successful generalist frugivore due to its capacity to compensate for a host characteristic that tends to decrease the population growth rate (r) with another that tends to increase it, resulting in high growth rate (KRAINACKER et al., 1987).

Considering the general infestation index of 7.45 puparia kg fruit⁻¹, banana would not fit as primary *C. capitata* host, since the minimum limit of 30 puparia kg fruit⁻¹ can be used to consider the host as primary (ARAÚJO, 2002). However, the infestation observed in the first sample from Santa Clara farm (146.08 puparia kg fruit⁻¹) was high and may indicate higher pest pressure than the other collection points, due to the presence of hosts in the vicinity, like mango orchards in production.

The association between banana and *C. capitata* was recorded for the first time in Brazil.

Acknowledgments

To Zenóbia Cardoso dos Santos and Suzany Aguiar Leite, from the Graduate Program in Agronomy (Plant Technology), State University of Southwestern Bahia, for the collaboration in the processing of samples.

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ERRATUM

<http://dx.doi.org/10.1590/0100-29452019091erratum>

Erratum of Scientific Communication: Sá, R.F. de; Oliveira, A. da S.; Oliveira, R. de C. C. de; Santos, J.C.M dos; Moreira, A.A.; Castellani, M.A.; First record of the association of banana (*Musa* sp.) and *Ceratitis capitata* (Wiedemann, 1824) in Brazil. *Rev. Bras. Frutic., Jaboticabal, 2019, v. 41, n. 1:* (e-091). <http://dx.doi.org/10.1590/0100-29452019091>

In de page 1, Resumo:

Line 2:

Where it reads: (Diptera: Tephritidae)

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Should read: ... configura-se

Line 11:

Where it reads: ...pupários/kg de fruto⁻¹ e pupários/kg de fruto⁻¹

Shoud read: ...pupários kg de fruto⁻¹ e pupários kg de fruto⁻¹

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