

FIRST SURVEY OF FRUIT FLY (DIPTERA: TEPHRITIDAE) AND PARASITOID DIVERSITY AMONG MYRTACEAE FRUIT ACROSS THE STATE OF BAHIA, BRAZIL¹

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ABSTRACT – The objective of this study was to evaluate the diversity of fruit fly (Diptera: Tephritidae) species that use myrtaceous fruit, particularly guava, as hosts in several localities in the state of Bahia and to determine the infestation rates, pupal viability rates, and fruit fly-parasitoid associations. Sampling of myrtaceous fruit was carried out in 24 municipalities in different regions in the state of Bahia. Four fruit fly species, *Anastrepha fraterculus*, *Anastrepha zenildae*, *Anastrepha sororcula*, and *Ceratitis capitata* were obtained from the collected fruit. Three parasitoid species (Hymenoptera: Braconidae) emerged from *Anastrepha* larvae/pupae, *Doryctobracon areolatus*, *Utetes anastrephae*, and *Asobara anastrephae*. *Doryctobracon areolatus* emerged from *A. fraterculus*, *A. sororcula* and *A. zenildae*; *Utetes anastrephae* emerged from *A. fraterculus* and *A. zenildae*; and *Asobara anastrephae* emerged from *A. fraterculus*. Fruit fly and myrtaceous fruit associations are reported for the first time in several municipalities in the state of Bahia. *A. zenildae* was found infesting *Syzygium malaccense* for the first time in Brazil.

Index terms: fruit flies, tephritids, braconids, parasitism, *Anastrepha*, *Ceratitis*.

PRIMEIRO LEVANTAMENTO DE MOSCA DAS FRUTAS (DIPTERA: TEPHRITIDAE) E DIVERSIDADE DE PARASITOIDES ENTRE FRUTOS DE MYRTACEAE EM TODO O ESTADO DA BAHIA, BRASIL

RESUMO – O objetivo deste estudo foi avaliar a diversidade de espécies de moscas-das-frutas (Diptera: Tephritidae) que usam frutos de mirtáceas, particularmente goiaba, como hospedeiro em várias localidades do Estado da Bahia e determinar os índices de infestação, taxa de viabilidade pupal e associações entre plantas hospedeiras, moscas-das-frutas e parasitoides. Coletas de frutos de mirtáceas foram realizadas em 24 municípios, em diferentes regiões do Estado da Bahia. Quatro espécies de moscas-das-frutas, *Anastrepha fraterculus*, *Anastrepha zenildae*, *Anastrepha sororcula* e *Ceratitis capitata*, foram obtidas dos frutos coletados. Três espécies de parasitoides (Hymenoptera: Braconidae) emergiram das larvas e pupas de *Anastrepha*, *Doryctobracon areolatus*, *Utetes anastrephae* e *Asobara anastrephae*. *Doryctobracon areolatus* emergiu de *A. fraterculus*, *A. sororcula* e *A. zenildae*; *Utetes anastrephae* emergiu de *A. fraterculus* e *A. zenildae*; e *Asobara anastrephae* emergiu de *A. fraterculus*. Associações entre moscas-das-frutas e mirtáceas são relatadas pela primeira vez em vários municípios do Estado da Bahia. *A. zenildae* foi registrada infestando *Syzygium malaccense* pela primeira vez no Brasil.

Termos para Indexação: moscas-das-frutas, tefritídeos, braconídeos, parasitismo, *Anastrepha*, *Ceratitis*.

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INTRODUCTION

Fruit flies (Diptera: Tephritidae) have a serious impact on fruit production worldwide due to both their direct economic impact (i.e. fruit damage caused by larval feeding) and strict quarantine restrictions imposed by several countries (ALUJA;MANGAN, 2008). These insects are among the most important agricultural pests in Brazil whose fresh fruit production is estimated at 43 million tons yearly (IBRAF, 2007). Brazil harbors a high diversity of fruit flies that infest a wide range of hosts in 54 plant families and the species of economic importance are restricted to some species in the genus *Anastrepha* (Schiner) and one introduced species, *Ceratitidis capitata* (Wiedemann) (ZUCCHI, 2007).

Myrtaceae is one of the most diverse plant families in Brazil with about 1,000 species. It is a well-represented family in the Atlantic Forest and comprises several commercially important species such as *Psidium guajava* L. (guava) and *Eugenia uniflora* L. (Surinam cherry) (GRESSLER et al., 2006). Brazil is the world's largest guava producer, and more than 50% of its total guava cultivated area is in the northeastern region, mainly in the states of Pernambuco and Bahia (MAPA, 2002; LIMA et al., 2008).

Several *Anastrepha* species infest myrtaceous fruit, and the genera *Psidium*, *Eugenia*, and *Syzygium* are some of the most important hosts. It is noteworthy that guava is infested by the highest diversity of fruit flies in Brazil, *C. capitata* and 11 species of *Anastrepha* (RAGA et al., 2006; ZUCCHI, 2007; SOUZA FILHO et al., 2009).

Fruit flies are considered key insect pests for fresh fruit production in Brazil. Although there has been an increase in fruit production in the state of Bahia, studies on fruit fly host associations, infestation levels, and natural enemies statewide are still scant. Most studies previously carried out in Bahia focused on a single location through fruit collection (SOUZA-FILHO et al., 2007; SILVA et al., 2008) or using traps (NASCIMENTO; ZUCCHI, 1981; DUTRA et al., 2009).

In the present study, we carried out fruit collections in several localities in the state of Bahia to evaluate the diversity of fruit fly species that use myrtaceous fruit, particularly guava, as hosts. Moreover, the infestation rates, pupal viability rates, and fruit fly-parasitoid associations were also determined. Fruit fly and myrtaceous fruit associations in several municipalities in the state of Bahia are reported for the first time.

MATERIAL AND METHODS

Sampling of myrtaceous fruit was carried out in 24 municipalities across different regions in the state of Bahia from April 2006 to April 2007. Samples of ripe or ripening fruit were collected randomly both from unsprayed tree canopies and fallen fruit at the ground level and brought to the Laboratório de Entomologia of Universidade Estadual de Santa Cruz (UESC), Ilhéus, Bahia, Brazil. The collected fruit were counted, weighed, and individually placed in plastic containers with a layer of vermiculite and covered with voile cloth to avoid reinfestation. All puparia obtained were placed in 30 mL plastic containers with a layer of vermiculite at the bottom and covered with voile cloth until adults emerged.

Fruit flies were identified based on the keys provided by Zucchi (2000) and Araujo and Zucchi (2006). Braconid parasitoids were identified based on the keys by Canal and Zucchi (2000). Voucher specimens were deposited at the Laboratório de Entomologia, UESC.

Infestation values reported in this study were based on the number of fruit fly larvae per Kg of fruit and on the number of fruit fly larvae per number of fruit according to Nascimento et al. (2000).

RESULTS AND DISCUSSION

A total of 857 fruit that represented five myrtaceous species and weighed 55.68 Kg were collected. From those fruit, 2,134 puparia were recovered. Of these puparia, a total of 1,263 fruit fly adults (628 males and 630 females) emerged with a pupal viability of 59.2%.

Four fruit fly species were recovered from the collected fruit, *Anastrepha fraterculus* (Wiedemann) (67.5%), *Anastrepha zenildae* Zucchi (15.1%), *Anastrepha sororcula* Zucchi (9.1%), and *C. capitata* (8.3%) (Table 1).

Infestation by *C. capitata* and *Anastrepha* spp. was detected in native fruit such as guava and *Psidium guineense* Swart. N (Brazilian guava), whereas the introduced host *Syzygium malaccense* (L.) Merr. & L.M. Perry (Malay apple) was infested solely by *Anastrepha* species (Table 1).

In the Recôncavo region, we found three *Anastrepha* species infesting myrtaceous fruit, *A. fraterculus* (68.9%), *A. sororcula* (17.8%), and *A. zenildae* (13.3%). Nascimento and Zucchi (1981) carried out a fruit fly survey in this region using traps and reported that the most frequent species

were *A. fraterculus*, *Anastrepha obliqua* (Macquart), *A. sororcula*, *Anastrepha distincta* Greene, and *Anastrepha serpentina* (Wiedemann). It was report the occurrence of *A. zenildae* in this region for the first time. Guava fruit hosted three *Anastrepha* species, *A. fraterculus*, *A. sororcula*, and *A. zenildae*, whereas the other two hosts collected in the region, *Myrciaria cauliflora* (Mart.) O.Berg. (jaboticaba) and Surinam cherry, were infested only by *A. fraterculus*. This is the first record of *A. fraterculus* infesting jaboticaba in Bahia (Table 1). Malavasi et al. (1980) reported *A. fraterculus*, *A. serpentina*, *A. pickeli* Lima, 1934 and *A. obliqua* in Conceição do Almeida and *A. antunesi* Lima in Santo Amaro da Purificação; however, they provided no specific information regarding fruit fly-host associations in this region.

In the southern region, *A. fraterculus* (77.6%), *A. sororcula* (6.0%), and *A. zenildae* (16.4%) were recovered. *A. fraterculus* was by far the most frequent species in all collections in this region. Our findings corroborate previous studies that show this species was also the most frequently recovered from systematic collections of guavas during the period of one to five years (SOUZA-FILHO et al., 2007; SILVA et al. 2010) as well as from traps (DUTRA et al., 2009). In the southern region, guava was also infested by three *Anastrepha* species, *A. fraterculus*, *A. sororcula*, and *A. zenildae*, while Surinam cherry was infested by *A. fraterculus* and *A. sororcula*. In a previous study, Souza-Filho et al. (2007) also reported *A. fraterculus*, *A. sororcula*, and *A. zenildae* infesting guava in one area in the municipality of Una. Silva et al. (2010) recovered *A. fraterculus*, *A. obliqua*, *A. sororcula*, and *A. zenildae* from guava in three areas also in the municipality of Una. In one of the collections in southern Bahia, *A. zenildae* was found infesting Malay apple for the first time in Brazil (Table 1).

In the central-southern region *A. fraterculus* (68.8%), *A. zenildae* (6.2%), and *A. sororcula* (25%) were recovered from collected guava fruit. This is the first record of fruit fly and myrtaceous host associations in the central-southern region of Bahia. Previous studies carried out in this region in the municipalities of Livramento de Nossa Senhora and Manoel Vitorino had focused on trapping or collection of Anacardiaceae fruit (NASCIMENTO; CARVALHO, 2000; SILVA et al., 2008). Nascimento and Carvalho (2000) reported a very high frequency of *C. capitata* (99.39%) in Livramento de Nossa Senhora. They indicated that this result was likely due to the presence of extensive mango groves and to the local climatic conditions. Silva et al. (2008) collected umbu fruit (*Spondias tuberosa* Arr. Cam.) in the municipality of Manoel Vitorino, and the only

fruit fly species recovered was *A. obliqua*.

In the central-northern region, the only fruit fly species recovered was *C. capitata* (100%) from both guava and Brazilian guava. In the northern region, *A. sororcula* (53.3%) and *A. zenildae* (46.7%) were recovered from fruit. In the western region, only *A. zenildae* (100%) was found infesting guava. We should be cautious in extrapolating the data from the fruit collected there to the entire western region, since our sampling was limited. These last three regions are all located in the semiarid of Bahia which is characterized by very low annual average rainfall (SEI, 2002). In a survey using McPhail traps in the area of the São Francisco sub-Middle Valley in the northern region of Bahia (Juazeiro - BA and Petrolina - PE), Nascimento and Carvalho (2000) reported the occurrence of *A. obliqua*, *A. pickeli*, *Anastrepha dissimilis* Stone, and *A. sororcula* in rural areas and *C. capitata* in urban areas. The presence of *A. zenildae* in Petrolina, state of Pernambuco, was reported by Haji & Miranda (2000). It is noteworthy that *A. sororcula* and/or *A. zenildae* were the dominant species recovered from guava collected in orchards in semiarid regions in the states of Minas Gerais and Rio Grande do Norte (ALVARENGA et al., 2009; ARAUJO et al., 2005). A pattern of species dominance is observed in the Brazilian Northeast, where *A. fraterculus* predominates in more humid regions while *A. zenildae* and *A. sororcula* predominate in the more arid regions. These latter two species appear to be better adapted than *A. fraterculus* to dry climates (MALAVASI et al., 2000).

The highest fruit fly infestation rates were observed in the samples from the southern region, where all reported myrtaceous fruit fly hosts were collected. The hosts *E. uniflora* and *P. guajava* were the preferred hosts of tephritids, with maximum rates of 306.7 pupae/Kg and 197.6 pupae/Kg, respectively (Table 1). These rates were higher than those reported by Malavasi et al. (1980) in different locations in Brazil.

Guava was the preferred host for *A. fraterculus* in Bahia. As well, guava was the myrtaceous species that hosted the highest diversity of fruit flies. These results corroborate results from several studies in other states in Brazil (MALAVASI et al., 1980; SILVA et al., 1996; SOUZA FILHO et al., 2009).

Interestingly, *C. capitata* was found only infesting fruit that were collected in urban areas, whereas *Anastrepha* spp. were found both in rural and urban areas. Similar results were reported in other regions in Brazil and Argentina by Malavasi et al. (2000) and Ovruski et al. (2003), respectively. The latter authors concluded that *C. capitata* seems

to adapt well to environments that have been highly disturbed.

Regarding parasitoids, three species were recovered *Doryctobracon areolatus* (Szépligeti) (79.8%), *Utetes anastrephae* (Viereck) (19%), and *Asobara anastrephae* (Muesebeck) (1.2%) (Hymenoptera: Braconidae). All parasitoids were recovered only from *Anastrepha* species. *D. areolatus* was by far the most predominant parasitoid species (Table 2). Previous studies similarly found *D. areolatus* to be the most predominant fruit fly parasitoid in southern Bahia (SOUZA-FILHO et al., 2007; SILVA et al., 2010) and in the Recôncavo region (CARVALHO, 2005) as well as throughout Brazil (ARAUJO; ZUCCHI, 2002; UCHÔA-FERNANDES et al., 2003).

The highest level of parasitism was detected in *Anastrepha* larvae/puparia recovered from Surinam cherry (51.0%). From these parasitized larvae/puparia emerged the three parasitoid species, *D. areolatus* (81.6 %), *U. anastrephae* (16.3%), and *A. anastrephae* (2.1%). High parasitism rates in Surinam cherry in Brazil have been reported by

other authors (AGUIAR-MENEZES; MENEZES, 1997; HICKEL, 2002). High parasitism in Surinam cherry is probably due to the small fruit size and fine exocarp since parasitoids may thus more easily locate larvae in the fruit endocarp. This higher frequency of *D. areolatus* in Surinam cherry may be explained by the ability of the parasitoid to parasitize fruit fly larvae in different stages in the fruit. This characteristic may render *D. areolatus* more competitive when compared to the other two recovered parasitoid species.

In this study, we report previously undocumented fruit fly and myrtaceous fruit associations and parasitoids in several municipalities in the state of Bahia (Table 1). Of the four fruit fly species that were reared from the collected fruit, *A. fraterculus* had the highest species frequency in areas with more humid climatic conditions whereas *C. capitata*, *A. zenilidae*, and *A. sororcula* showed higher frequency in the semiarid region. Our results further confirm guava as the preferred host for *A. fraterculus* wherever both/ either are found throughout Brazil.

TABLE 1 - *Anastrepha* species and braconids reared from myrtaceous collected in the state of Bahia, Brazil.

Region	Municipality	Host plant species	N° of fruit sampled	Kg of fruit	Total n° of pupae	N° of pupae/Kg of fruit	N° of Adults (Males / Females)	Fruit fly species
North	Juazeiro	<i>P. guajava</i> (guava)	56	4.30	51	11.9	20 / 15	8 <i>A. sororcula</i> 7 <i>A. zenilidae</i>
	Itaberaba	<i>P. guajava</i> (guava)	57	4.60	85	18.5	41 / 36	36 <i>C. capitata</i>
Central-West	Jacobina*	<i>P. guajava</i> (guava)	9	1.00	33	33.0	11 / 10	10 <i>C. capitata</i>
		<i>P. guineense</i> (Brazilian guava)	24	0.68	24	35.3	4 / 7	7 <i>C. capitata</i>
West	Barreiras*	<i>P. guajava</i> (guava)	25	2.30	15	6.5	0 / 2	2 <i>A. zenilidae</i>
	Itapetinga*	<i>P. guajava</i> (guava)	2	0.40	2	5.0	0 / 2	1 <i>A. fraterculus</i> 1 <i>A. zenilidae</i>
	Itiruçu *	<i>P. guajava</i> (guava)	10	2.05	29	14.1	10 / 4	4 <i>A. fraterculus</i>
Central-South	Jitaúna *	<i>P. guajava</i> (guava)	95	7.30	90	12.3	16 / 16	16 <i>A. fraterculus</i>
	Milagres *	<i>P. guajava</i> (guava)	13	0.65	15	23.1	7 / 8	8 <i>A. sororcula</i>
	Ubaira *	<i>P. guajava</i> (guava)	9	0.75	7	9.3	1 / 2	1 <i>A. fraterculus</i> 1 <i>A. zenilidae</i>

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	Camamu	<i>P. guajava</i> (guava)	6	1.50	108	72.0	12 / 27	17 <i>A. fraterculus</i> 7 <i>A. sororcula</i> 3 <i>A. zenildae</i>
Recôncavo	Taperoá	<i>P. guajava</i> (guava)	4	1.20	45	37.5	13 / 12	8 <i>A. fraterculus</i> 1 <i>A. sororcula</i> 3 <i>A. zenildae</i>
		<i>E. uniflora</i> (Surinam cherry)	64	0.50	17	34.0	3 / 1	1 <i>A. fraterculus</i>
	Valença	<i>M. cauliflora</i> (jaboticaba)	26	1.00	3	3.0	2 / 1	1 <i>A. fraterculus</i> **
		<i>P. guajava</i> (guava)	10	1.60	20	12.5	14 / 4	4 <i>A. fraterculus</i>
	Barrolândia	<i>E. uniflora</i> (Surinam cherry)	50	0.70	34	48.6	20 / 8	2 <i>A. fraterculus</i> 6 <i>A. sororcula</i>
	Gandu*	<i>P. guajava</i> (guava)	14	1.50	49	32.7	11 / 15	13 <i>A. fraterculus</i> 2 <i>A. sororcula</i>
	Ibirataia*	<i>P. guajava</i> (guava)	50	2.80	60	21.4	11 / 18	16 <i>A. fraterculus</i> 1 <i>A. sororcula</i> 1 <i>A. zenildae</i>
	Ilhéus	<i>P. guajava</i> (guava)	14	1.70	32	18.8	15 / 17	17 <i>A. fraterculus</i>
	Ipiaú*	<i>P. guajava</i> (guava)	14	0.95	43	45.3	14 / 14	12 <i>A. fraterculus</i> 2 <i>A. sororcula</i>
	Itabuna	<i>P. guajava</i> (guava)	12	1.00	93	93.0	9 / 18	5 <i>A. fraterculus</i> 13 <i>A. zenildae</i>
	Itacaré*	<i>P. guajava</i> (guava)	1	0.15	15	100.0	8 / 5	5 <i>A. fraterculus</i>
South	Itapé*	<i>P. guajava</i> (guava)	34	2.85	350	122.8	165/160	89 <i>A. fraterculus</i> 13 <i>A. sororcula</i> 58 <i>A. zenildae</i>
	Nova Ibiá*	<i>P. guajava</i> (guava)	15	1.65	40	24.2	15 / 12	12 <i>A. fraterculus</i>
	Porto Seguro	<i>S. malaccense</i> (Malay apple)	10	2.30	32	10.0	10 / 12	12 <i>A. fraterculus</i>
		<i>P. guajava</i> (guava)	12	1.50	15	13.9	7 / 7	7 <i>A. fraterculus</i>
		<i>E. uniflora</i> (Surinam cherry)	130	0.75	230	306.7	8 / 11	11 <i>A. fraterculus</i>
	Una	<i>P. guajava</i> (guava)	22	2.50	494	197.6	164/158	150 <i>A. fraterculus</i> 5 <i>A. sororcula</i> 3 <i>A. zenildae</i>
		<i>P. guineense</i> (Brazilian guava)	13	0.50	20	40.0	4 / 11	11 <i>A. fraterculus</i>
		<i>S. malaccense</i> (Malay apple)	50	4.60	60	13.0	9 / 10	6 <i>A. fraterculus</i> 4 <i>A. zenildae</i> **
	Wenceslau Guimarães*	<i>P. guajava</i> (guava)	6	0.40	23	57.5	4 / 7	7 <i>A. fraterculus</i>
	Total		857	55.68	2,134		628/630	

* First report of fruit flies infesting fruit in this municipality. ** First report of this fruit fly and host plant association.

TABLE 2 - Host plant/ fruit fly/ parasitoid associations and parasitism rates in myrtaceous collected in different municipalities in Bahia, Brazil.

Municipalities	Host plant species	Fruit fly species	Parasitoids	Parasitism rate (%)
Barrolândia	<i>E. uniflora</i>	6 <i>A. sororcula</i> 2 <i>A. fraterculus</i>	6 <i>D. areolatus</i>	21.4
Itabuna	<i>P. guajava</i>	13 <i>A. zenildae</i> 5 <i>A. fraterculus</i>	3 <i>D. areolatus</i>	10.0
Itapé	<i>P. guajava</i>	89 <i>A. fraterculus</i> 58 <i>A. zenildae</i> 13 <i>A. sororcula</i>	5 <i>U. anastrephae</i> 4 <i>D. areolatus</i>	2.7
Nova Ibiá	<i>P. guajava</i>	12 <i>A. fraterculus</i>	5 <i>D. areolatus</i>	15.6
Una	<i>E. uniflora</i>	11 <i>A. fraterculus</i>	34 <i>D. areolatus</i> 8 <i>U. anastrephae</i> 1 <i>A. anastrephae</i>	69.3
	<i>P. guineense</i>	11 <i>A. fraterculus</i>	1 <i>D. areolatus</i>	6.25
	<i>S. malaccense</i>	6 <i>A. fraterculus</i>	14 <i>D. areolatus</i>	47.2

4 *A. zenildae* 3 *U. anastrephae* 502, 2008.

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